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THE EFFECT OF FAT UPON THE DIGESTION OF NUTRIENTS BY DAIRY COWS[1]

H. L. Lucas and J. K. Loosli

IN A series of studies at the Cornell Experiment Station, which have been summarized by Maynard and Associates (1941), slightly more milk and fat were produced when cows were fed grain mixtures containing 4 per cent or more of ether extract than when fed concentrates containing less than 2 per cent of ether extract. These workers recognized that increased production may have been caused by a number of factors other than fat per se. It appeared possible that a more efficient absorption of nutrients had occurred on the higher fat than on the lower fat rations. Digestion trials were, therefore, undertaken to study this problem.

Experimental Procedure

Two series of digestion trials were carried out. In all trials timothy hay and beet pulp were fed with a concentrate mixture. The hay, beet pulp, and concentrates were fed in the ratio of 7 to 8 to 10 parts by weight respectively. There were no feed refusals.

Holstein cows were used in the studies. The excreta were separated using the funnel and harness described by Forbes and Associates (1937). Once each day the feces were thoroughly mixed and aliquot samples were composited in sealed jars with 95 per cent alcohol containing 1 per cent of sulfuric acid as a preservative. At the end of the collection periods the composite fecal samples were mixed, dried at 60 degrees centigrade for 2 days, equilibrated to air dryness, then ground for chemical analyses. Fecal collections were made after a preliminary period of 10 to 13 days of constant feed intake. All fat analyses and references thereto represent total ether-extractable material.

Series I

The high-fat and low-fat concentrate mixtures used in series I were composed of barley 21 parts by weight, oats 15, wheat bran 5, molasses 5, beet pulp 10, bone meal 1, salt 1, cottonseed meal 10, linseed meal 11, soybean meal 11, and corn distillers' dried grains 10. The oil meals and corn distillers' grains used in the low-fat mixture were solvent extracted, whereas the oil meals used in the high-fat mixture were processed by either the expeller or hydraulic method, and the distillers' grains in the high-fat mixture

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were an unextracted commercially available product. The average composition of the two concentrate mixtures, of the beet pulp and timothy hay, and the calculated composition of the overall high-fat and low-fat rations are shown in table 1.

TABLE 1.—THE COMPOSITIONS OF THE VARIOUS FEEDS AND THE CALCULATED COMPOSITIONS OF THE COMPLETE RATIONS USED IN SERIES I

Feed	Dry matter	Crude protein	Ether extract	N-free extract	Crude fiber	Ash
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
High-fat concentrate	88.5	21.4	4.4	48.8	8.0	5.9
Low-fat concentrate	88.3	22.5	1.8	49.4	8.6	6.0
Dried beet pulp	87.9	9.2	0.8	55.1	19.7	3.1
Timothy hay	91.3	4.9	2.0	47.1	33.8	3.4
High-fat ration	89.1	12.9	2.6	50.4	19.0	4.3
Low-fat ration	89.0	13.3	1.6	50.6	19.2	4.3

TABLE 2.—THE EFFECT OF DIFFERENT LEVELS OF FAT INTAKE UPON THE DIGESTION OF NUTRIENTS BY DAIRY COWS. SERIES I

Ration	Cow number	Apparent digestibility				
		Dry matter	Crude protein	Ether extract	N-free extract	Crude fiber
		per cent	*per cent*	*per cent*	*per cent*	*per cent*
High fat	5	69.0	67.6	65.3	77.6	58.1
	6	68.2	67.9	64.7	76.4	56.3
	10	71.0	68.3	66.7	78.5	59.9
	11	70.6	69.7	67.2	78.2	59.8
	14	75.6	64.5	69.0	78.4	60.5
	Average	70.9	67.6	66.6	77.8	58.9
Low fat	5	69.8	69.5	47.5	77.6	60.4
	6	67.2	67.9	46.0	76.1	54.5
	10	69.7	70.4	45.8	76.8	59.3
	11	70.6	71.4	41.9	78.1	60.8
	14	72.4	69.8	49.4	80.3	63.4
	24	69.5	67.6	55.3	77.3	58.4
	26	70.8	68.5	53.5	78.5	60.3
	Average	70.0	69.3	48.5	77.8	59.6
	Average omitting 24 & 26	69.9	69.8	46.1	77.8	59.7

In series I the nutrient intakes of all animals were held at approximately two and a half times maintenance as calculated from Morrison's (1936) standard "recommended for good cows." The intake of air-dry matter for a given animal was held constant throughout the feeding of both high- and low-fat rations. Seven animals in all were used during the comparison, but only five animals received both the rations. Collection periods in this series were ten days in length.

The coefficients of apparent digestibility of the rations are presented in table 2.

These data fail to indicate any important difference in the apparent digestibility of the rations studied. Statistical analyses showed that the differences in digestibility of the various nutrients between diets were not significant, except for ether extract. The significantly higher digestibility of ether extract on the high-fat rations would be expected since the effect of metabolic fat was relatively less, and the ether extract of the low-fat rations probably contained a greater proportion of non-fat residue which would be poorly absorbed. Using the composition of the complete rations given in table 1 and the average apparent digestibility presented in table 2, it was calculated that the high-fat and low-fat rations contained 63.0 and 61.8 per cent total digestible nutrients respectively. This difference is attributable solely to the difference in fat content. It appears that there was no effect of the fat on the apparent digestibility of other nutrients.

TABLE 3.—THE COMPOSITIONS OF THE VARIOUS FEEDS AND THE CALCULATED COMPOSITIONS OF THE COMPLETE RATIONS USED IN SERIES II

Feed	Dry matter	Crude protein	Ether extract	N-free extract	Crude fiber	Ash
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Partially heated soybean meal	89.4	43.5	0.6	32.9	5.6	6.8
Toasted soybean meal	89.6	43.9	0.5	32.9	5.5	6.8
Ground soybeans	91.4	36.5	17.5	27.0	4.5	5.9
Toasted meal plus soybean oil	90.9	36.4	16.1	28.2	4.5	5.7
Toasted meal plus corn oil	88.9	36.5	13.8	27.6	4.6	6.4
Toasted meal plus soybean fatty acids	89.4	37.2	14.7	27.9	4.8	4.8
Dried beet pulp	89.0	9.4	0.6	56.4	19.6	3.0
Timothy hay	92.2	4.5	1.8	49.2	33.8	2.9
Ration containing						
Partially heated meal	90.1	21.7	1.0	45.0	18.0	4.5
Toasted meal	90.1	21.8	0.9	45.0	17.9	4.5
Ground soybeans	90.9	18.9	7.7	42.6	17.5	4.2
Meal plus soybean oil	90.7	18.8	7.2	43.1	17.5	4.1
Meal plus corn oil	89.9	18.9	6.2	42.8	17.6	4.4
Meal plus fatty acids	90.1	19.1	6.6	43.0	17.6	3.7

Series II

In this series various soybean products or combinations of them, with one per cent each of bone meal and salt added, served as the concentrate portion of the rations. The chemical composition of the various concentrates, the timothy hay and dried beet pulp, and the composition of the complete rations used are shown in table 3. Both soybean oil and corn oil were used in the soybean meal-plus-oil rations. The soybean meals, ground soybeans, and soybean oil were all obtained from the same batch of beans. Both soybean meals were solvent extracted. The oils were crude products and the fatty acids were obtained from soybean oil.

In this series the animals were fed at a level of about 2.0 times their maintenance requirements except in the case of cows 12 and 14 which received respectively 1.5 and 2.5 times their maintenance needs. With one exception, the amounts of feed consumed remained constant for a given animal on all rations. The intake of cow No. 3 was lowered to about three-quarters of her normal intake during the feeding of the meal-plus-fatty-acid ration because she had ceased lactating.

Effects on Digestibility

The coefficients of apparent digestibility are shown in table 4. A study of these data reveals a lower digestibility of the dry matter, nitrogen-free extract and crude fiber in the case of the rations containing ground soybeans and soybean meal plus oil, than for the other rations.

There were large differences in the apparent digestibility of the ether extract among the various rations. Statistical analyses indicated that the ether extract of the three high-fat rations was significantly more digestible than the ether extract of the low-fat rations. Similarly, the ether extract of the rations containing oil and fatty acids was significantly more digestible than the ether extract of the ration containing ground soybeans. The extremely low and negative values obtained for the apparent digestibility of ether extract in the two soybean-meal rations would be expected because of the very low ether-extract content of these rations.

The lower ether-extract digestibility on the ground-soybean ration than on the rations containing added oil or fatty acids is in agreement with the observations of Wilbur and coworkers (1939), who found that the ether-extract content of the feces of animals receiving soybeans was considerably greater than the ether-extract content of the feces of animals receiving equivalent amounts of soybean meal with soybean oil added. The two soybean-meal rations and the ration containing fatty acids were practically identical with respect to digestibility of crude fiber, but on the ground-soy-

TABLE 4.—THE APPARENT DIGESTIBILITIES OF NUTRIENTS IN RATIONS CONTAINING VARIOUS SOYBEAN PRODUCTS. SERIES II

Ration containing	Cow number	Apparent digestibility				
		Dry matter	Crude protein	Ether extract	N-free extract	Crude fiber
		per cent	*per cent*	*per cent*	*per cent*	*per cent*
Partially heated solvent extracted soybean meal	3	75.8	83.5	−3.3	80.5	67.0
	14	74.4	83.6	9.1	79.5	63.6
	37	75.8	81.3	−0.8	81.0	67.6
	Average	75.3	82.8	1.7	80.3	66.1
Toasted solvent extracted soybean meal	3	73.7	80.1	−17.2	79.4	65.3
	12	75.3	82.5	−22.7	80.9	68.1
	14	75.2	83.8	18.0	79.9	63.0
	37	74.8	81.0	−16.1	80.1	66.6
	41	75.9	82.1	−6.7	81.2	66.8
	Average	75.0	81.9	−14.9	80.3	66.0
Ground soybeans	3	71.7	80.3	59.2	78.1	59.9
	12	71.5	80.9	54.4	78.4	61.3
	14	70.7	81.2	58.3	76.8	59.5
	37	71.8	80.1	57.0	78.3	60.4
	Average	71.4	80.6	57.2	77.9	60.3
Toasted solvent extracted soybean meal plus oil	3*	72.5	81.3	66.2	78.0	61.1
	12**	73.5	81.0	70.9	78.8	63.6
	37**	73.0	81.8	62.7	78.6	62.1
	Average	73.0	81.4	66.6	78.5	62.3
Toasted solvent extracted soybean meal plus fatty acids	3	76.8	85.2	69.6	82.2	65.7
	12	76.2	81.9	76.3	81.6	66.4
	41	77.0	85.7	71.4	81.3	67.3
	Average	76.7	84.3	72.4	81.7	66.5

* Received soybean oil.
** Received corn oil.

bean and the oil-containing rations the digestibility of the crude-fiber fraction was considerably depressed. Statistically there was no significant difference between the soybean ration and the ration containing oil, but the crude-fiber digestibility of these two rations was significantly lower than that of the other three. The significance and direction of differences among rations from the standpoint of nitrogen-free-extract digestibility were identical with those for crude fiber.

Although certain trends are noted in the data, the statistically significant differences as regards protein digestibility were somewhat irregular. From this standpoint the fatty-acid ration was significantly higher than both the soybean and the oil-containing rations, but was not significantly different from either of the meal rations. On the other hand, the partially-heated-meal ration was significantly higher than the ground-soybean ration but was not significantly different from the oil-containing ration. The toasted-meal ration was not significantly different from the other rations. In light of the irregularity of effects, it is not possible to conclude that there were any real differences among rations as regards protein digestibility.

TABLE 5.—THE TOTAL DIGESTIBLE NUTRIENT CONTENT OF THE RATIONS CONTAINING SOYBEAN PRODUCTS

Ration containing	Total digestible nutrients
	per cent
Partially heated soybean meal	66.0
Toasted soybean meal	65.5
Ground soybeans	78.9
Toasted soybean meal plus oil	70.1
Toasted soybean meal plus soybean fatty acids	73.7

Considering the lowered digestibility of all constituents on the soybean ration, it would appear that raw soybeans are less digestible for dairy cows than are solvent-extracted soybean meals. Since the addition of a large amount of oil to soybean meal depressed the digestibility of the crude fiber and nitrogen-free extract but had little effect upon protein digestibility it might be postulated that excess oil is detrimental to the breakdown of cellulose by fermentive action in the rumen. Clearly more direct evidence is needed on this problem. The addition of fatty acids caused no depression of digestibility, possibly because the free fatty acids were rapidly saponified in the rumen.

Collection periods in this series varied from 10 to 20 days in length, most of the trials being of 19 or 20 days' duration. The long and short collections were distributed among the various rations. In all trials 14 or more days in length, the collection periods were divided into 2 parts. In all cases, the agreement between separate parts of collections except for ether-extract was remarkably good. Statistical analyses including all collections on the basis of ten days or less, showed the same differences as significant as were shown on the basis of the average values for each trial regardless of length. In some cases significance was increased.

The total digestible nutrients of each of the five rations were calculated from the ration composition as shown in table 3 and the average coefficients

of apparently digestibility given in table 4. The values are shown in table 5.

The total digestible nutrients of the ration for each animal for each trial were also calculated in order to test the results statistically. It was found that the total-digestible-nutrient content of the ration containing fatty acids was significantly greater than the total-digestible-nutrient content of all the other rations. The rations containing soybeans and oil were not significantly different from each other, but both were significantly higher than either of the soybean-meal rations. Comparing the high-fat rations with the low-fat rations, it was found that the differences in total-digestible nutrients were definitely not as great as would be expected from the differences in ether-extract content, except in the case of the ration containing fatty acids.

Effects on Production

Certain cows were in milk during the digestion trials and some observations were made upon the relative production values of the various rations. These production data (table 6) are of interest because it is not possible to correlate the apparent intake and fat content of certain of the rations with the lactation response observed.

TABLE 6.—THE EFFECT ON MILK AND FAT PRODUCTION OF RATIONS CONTAINING VARIOUS SOYBEAN PRODUCTS

Ration containing	Daily feed intake			Average daily production*		
	Air-dry ration	T.D.N.	Ether extract	Milk	Fat	4% F.C.M.
	pounds	*pounds*	*pounds*	*pounds*	*per cent*	*pounds*
Cow number 3						
Soybean meal	25.6	16.9	0.26	21.3	3.55	19.8
Ground soybeans	25.6	17.6	1.97	21.6	4.30	22.6
Soybean meal	25.6	16.7	0.23	23.7	3.00	20.2
Soybean meal plus soybean oil	25.6	17.9	1.84	15.1	3.35	13.6
Soybean meal	25.6	16.7	0.23	20.9	3.20	18.3
Cow number 37						
Soybean meal	26.8	17.7	0.27	24.4	3.40	22.2
Ground soybeans	26.8	18.5	2.06	24.4	4.60	26.6
Soybean meal	26.8	17.6	0.24	24.6	3.30	21.9
Soybean meal plus corn oil	26.8	18.8	1.66	16.1	3.90	15.9
Cow number 41						
Soybean meal	23.0	15.1	0.21	24.5	3.20	21.6
Soybean meal plus soybean fatty acids	23.0	17.0	1.52	17.0	3.20	15.1
Soybean meal	23.0	15.1	0.21	20.4	3.20	18.0

* Production during the last 20 days of a period 30 days or more in length.

Considering the production obtained during the feeding of the partially heated and toasted meal rations as normal, it is seen that the feeding of the ground soybeans caused a marked increase in the fat content of the milk with practically no change in milk yield. On the other hand, the feeding of the oils or fatty acids caused a marked drop in milk flow with little change in fat percentage.

The increase in fat content of the milk during the feeding of ground soybean is in agreement with numerous reports from the Indiana station (Wilbur *et al.*, 1935). The observation made here that feeding added oil markedly depressed milk flow without affecting fat percentage is at variance with studies reported in the literature. The Indiana workers (Bratton *et al.*, 1938) found that added soybean oil produced some increase in fat percentage with no effect on milk flow. The work of Gibson and Huffman (1939) also indicates the beneficial effect of soybean oil, but these same authors later reported (1940) that they were unable to confirm their first results. Williams *et al.* (1939) observed that ground soybeans depressed milk flow but increased total fat yield, whereas, replacing the soybeans equivalently with soybean meal and soybean oil caused an increased milk flow but a decrease in total fat yield. Allen and Fitch (1941) have observed depressing as well as beneficial effects of added soybean oil and corn oil upon the production of milk and fat. Sheehy (1931) reported that soybean oil caused no change in the fat content of milk or total fat production. This same author found that large amounts of linseed oil depressed the fat percentage but small amounts had no effect.

The increased production of fat-corrected milk during the feeding of soybeans is somewhat more than would be expected from the increase in total-digestible-nutrient intake. On the other hand, the rations containing oil and fatty acids, which were highest in total-digestible-nutrient content, gave the poorest production results. No observations on body weight changes were made. It is clear that further work is necessary to establish the production value of these products and the mechanism of the effect of fat in the ration both on digestibility and production.

Summary

Digestion studies were conducted comparing the effects of different levels and different sources of fat upon the apparent digestibility of nutrients in the rations of dairy cows. The differences in fat intake were obtained by using concentrates of different ether-extract content. Timothy hay and dried beet pulp were also fed.

There was no difference in the apparent digestibility of rations containing 1.6 and 2.6 per cent ether extract. The difference in fat level of these two

rations was obtained by using concentrate mixtures containing 1.8 and 4.4 per cent ether extract.

Using soybean products as the sole concentrates, rations containing 1.0 and 7.0 per cent of ether extract were studied. The crude fiber and nitrogen-free extract of rations containing soybeans and solvent-extracted soybean meal plus corn or soybean oil were less digestible than the crude fiber and nitrogen-free extract of rations containing solvent-extracted soybean meal. The ether extract of rations containing soybean meal plus oil or plus fatty acids was more digestible than the ether extract of a ration containing soybeans. Although protein digestibility was lowest on the soybean ration and highest on the ration containing soybean meal plus fatty acids, the significance of the difference in protein digestibility was questionable.

The ration containing soybeans caused a marked increase in fat percentage with practically no change in milk flow. The rations containing either oil or fatty acids caused a pronounced decrease in milk flow with little change in fat percentage. The production of milk fat and fat-corrected milk, bore no consistent relation to the actual intakes of ether extract and total digestible nutrients.

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POTENTIAL FERTILITY OF OVA FROM EWES TREATED WITH GONADOTROPINS[1]

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THERE is ample evidence from both laboratory and farm animals that ovulation can be produced by various treatments with gonadotropic hormones. Relatively few studies, however, have been made on the fertilizability of the resulting ova. Fertility has been demonstrated in the laboratory animals by Engle (1927, 1931) working with mice, Cole (1937a) and Evans and Simpson (1940) with rats, and Pincus (1940) with rabbits. There has been little evidence, however, as to the percentage fertility of the eggs or as to identity of factors affecting the fertility.

Zavadovskii *et al.* (1935) and Casida *et al.* (1940, 1943) were able to produce ovulation in the early part of the estrous cycle in cows, but efforts to fertilize the ova were unsuccessful. The latter workers found that over half of the eggs from induced ovulations in cows late in the estrous cycle were fertilized, and only a small percentage of artificially ovulated ova in calves underwent cleavage.

Parkes and Hammond (1940) and Hammond *et al.* (1942) obtained fertilized ova from the oviducts of ewes treated with horse pituitary extracts shortly before the expected onset of estrus. The latter authors were unable to produce ovulation early in the cycle. Loginova and Lopyrin (1938) reported the birth of as many as five lambs when ewes were treated in the latter part of the estrous cycle with pregnant mare serum.

Cole and Miller (1933) using pregnant mare serum and Hammond, *et al.* (1942) using pregnant mare serum and estrogen reported fertile matings when ovulation was induced in the ewe during anestrus. The former workers reported a high percentage of success, but later work by Cole (1937b) suggested that unknown factors could complicate repetition of the results.

The study to be reported here, has to do with the identification of some of the factors affecting the potential fertility of sheep ova from follicles matured by gonadotropic hormone injections.

Materials and Methods

Native medium wool ewes varying in age from approximately 1½ to 7 years were used in the first year's work, and "solid-mouth" ewes predomi-

[1] Paper from the Department of Genetics No. 318. This work was supported in part by a grant from the Wisconsin Alumni Research Foundation. Further acknowledgment is due to personnel provided by the National Youth Administration.

nantly of fine wool type from Montana were used the second year.

Four purebred rams (Hampshire, Shropshire, and Southdown) from the University flock were used both for teasers and, by the use of an artificial vagina, for the collection of semen used in artificial inseminations. Only semen satisfactory from the standpoint of concentration, motility, and color was used for insemination. In addition to observations made at the time of collection, survival tests were run at intervals on the sperm of each ram, and from them no reason appears to ascribe differences in fertility of eggs to variation in potential fertility of the sperm.

Eleven different batches of follicle-stimulating extract, all prepared by the "trypsin-digestion" method of McShan and Meyer (1940) were used in these studies. (Each batch will later be referred to by number.) Four batches were used in 1940, and seven in 1941. A dosage of 0.5 gram-equivalent of this extract when given in nine semi-daily injections to 21-day-old female rats produced ovaries virtually free from luteinization and averaging, on three rats, from 22 to 105 mgm. in weight. Upon the basis of the rat assays, dosages for the sheep were calculated so that the animals on the different batches received approximately equal dosages in terms of rat units.

The luteinizing extract was prepared by a method developed by McShan (unpub.). This preparation elicited no response when assayed alone in the manner described for the follicle-stimulating extract, but when given in combination with the latter preparation, produced augmentation of ovarian weight and extensive luteinization of follicles.

The unfractionated preparation was an aqueous extract of acetone desiccated pituitary powder and probably contained other water-soluble hormones of the pituitary gland in addition to gonadotropins. It gave both follicular stimulation and luteinization when assayed on immature rats.

The pregnant mare serum was furnished through the courtesy of the Upjohn Company, and was untreated except for Seitz filtering. It was frozen for storage, and was thawed and injected without further treatment.

The pituitary extracts were stored at approximately 4° C. The quantity of extract to be injected was, as a rule, dissolved in 5 cc. of distilled water. Subcutaneous injections were made in the neck or shoulder region and intravenous injections into either jugular vein.

Experimental Procedure

Ewes were treated with pituitary extracts in three different reproductive stages, which for convenience are indicated as (1) "follicular," (2) "luteal," and (3) "anestrous." The treatment consisted of a single subcutaneous injection of follicle-stimulating extract on each of four consecutive days, and on the sixth day, an intravenous injection of either 10 gram-equivalents of

luteinizing extract (used in 1940) or one gram-equivalent of unfractionated extract (used in 1941) was given. All ewes were artificially inseminated on the day of the intravenous injection and again on the following day.

Treatment of the "follicular" ewes was initiated twelve days after the beginning of an estrous period. The intravenous injection was made seventeen days after the beginning of the previous estrus and thus was on the day that natural estrus would have been expected. All except two of the ewes were in estrus at that time, and in those two, heat had terminated shortly before the injection. The treatment can be considered as interacting with the physiological changes which normally result in the heat period of the ewe.

The treatment of the luteal ewes was initiated three days after the beginning of estrus and the intravenous injection thus came on the ninth day of the estrous cycle. The anestrous ewes were of course treated without reference to an estrous cycle. The experimental procedure used on the anestrous ewes treated with pregnant mare serum will be presented in connection with the experimental results.

Experimental Results and Discussion

Follicular Ewes. A total of twenty-five "follicular" ewes was treated during the two years. Examinations of the ova were made 2–5 days after the intravenous injections in 1940, and of the six treated ewes five were found to be pregnant. (Table 1.) The six had an average of 18.0 corpora lutea, 8.5 normal appearing embryos, and 3.3 unfertilized eggs and fragmenting embryos. The normal embryos ranged from 2 to 16 cells, even within the same ewe, in some cases. The reason for this is not clear, but possibly ovulation occurred over a period of time, and thus the embryos were of different ages, or it may be that such variation in rate of development is normal for the ewe; also some of the embryos possibly were dead but had not yet fragmented. Of a total of 74 eggs recovered from the six ewes, 76 per cent were cleaving, and 69 per cent were developing normally. One other ewe, No. 23 treated with 205AS had 21 corpora lutea, but she is not included because of an incomplete search for eggs.

Eleven of 18 ewes examined three days after treatment in 1941 had fertilized eggs. (Table 1.) In these 18 there was an average of 26 corpora lutea, 5.7 normal embryos, and 10 unfertilized eggs and fragmenting embryos. Of the total of 283 ova, 39 per cent had been fertilized and 36 per cent were developing normally.

Probably the most striking difference between the two years' results is the higher average fertility in 1940. In addition to this there is evidence from the greater average number of corpora lutea and of recovered eggs that

TABLE 1. POTENTIAL FERTILITY OF ARTIFICIALLY MATURED OVA IN FOLLICULAR EWES

Ewe no.	Extract no.	No. C.L. in ovaries	Normal embryos recovered	Unfert. eggs or abnormal embryos recovered
		1940 season		
1	FSH403WS	12	5 (8–16 cell)	4 (8–16 cell frag.)
5	FSH403WS	4	0	2 unfert.
32	FSH403WS	13	2 (16 cell)	3 unfert.; 1 cleav. abnor.
36	FSH403WS	33	19 (2–16 cell)	4 unfert.
	Ave.	15.5	6.5	3.5
11	FSH405WS	21	12 (3–16 cell)	8 unfert.
28	FSH405WS	25	13 (2–16 cell)	1 unfert.
	Ave.	23	12.5	4.5
Ave. for 1940		18.0	8.5	3.8
		1941 season		
49	FSH220WS	37	23 (2–8 cell)	1 unfert.; 6 cleav. abnor.
52	FSH220WS	33	4 (8 cell)	23 unfert.
	Ave.	35.0	13.5	15.0
55	FSH312WS	15	0	10 unfert.
63	FSH312WS	29	0	13 unfert.
85	FSH312WS	36	0	11 unfert.
86	FSH312WS	21	7 (4–8 cell)	8 unfert.
88	FSH312WS	37	2 (2–3 cell)	15 unfert.; 1 cleav. abnor.
90	FSH312WS	52	0	29 unfert.
	Ave.	31.7	1.5	14.5
77	FSH313WS	24	0	13 unfert.
80	FSH313WS	20	0	12 unfert.
	Ave.	22	0	12.5
60	FSH314LS	33	2 (2–8 cell)	19 unfert.
64	FSH314LS	13	0	4 unfert.
	Ave.	23	1	11.5
72	FSH404BH	8	4 (4–8 cell)	1 unfert.
79	FSH404BH	12	11 (8 cell)	0
83	FSH404BH	25	14 (8 cell)	6 unfert.; 2 cleav. abnor.
89	FSH404BH	19	5 (8 cell)	7 unfert.
	Ave.	16.0	8.5	4.0
51	FSH311WS	17	14 (3–8 cell)	0
66	FSH311WS	37	16 (8 cell)	0
	Ave.	27	15	0
Ave. for 1941		26	5.7	10.0

the 1941 ewes were stimulated to a somewhat greater extent than those of 1940.

The lower average fertility became apparent about midway in the 1941 experiment, and from then on considerable attention was given to locating possible causes for it. Examination of the data (analyses not reported in detail here) indicated significant differences between ewes in the probability of an egg being fertilized. The analyses, however, showed no apparent relation between fertility of eggs and the age or previous history of the ewes, nor the time within the breeding season at which they were treated.

Statistical studies* failed to show significant fertility differences between batches of follicle-stimulating extract in 1940, but did show differences in 1941 which were significantly greater than those between ewes treated the same ($P < 0.01$). The fertility in all ewes treated with 312WS, 313WS, and 314LS was very low (Table 1). Nos. 311WS and 404BH gave results comparable to those obtained in 1940. Sufficient data were not available with which to classify 220WS. There was no apparent association between degree of fertility on a batch of extract and the presence or absence of slightly luteinized ovaries in the rats tested on it.

The possible relationship between certain estrous phenomena, observed in connection with treatment, and fertility was studied, both in relation to individual ewes and to groups of ewes treated with the various batches of extract. There was no relation between the length of time in heat and fertility in the individual ewes, and the average length of estrus did not differ much between ewes in the different groups. There was a tendency for fertility to be associated with the length of the part of the estrous period which came after the intravenous injection. This was observed for individual ewes, and similarly, ewes in the groups giving low fertility tended to have a short post-injection portion of the estrous period. Neither of these relationships was statistically significant, but both were approaching significance and might prove to be important.

Since characterization of the different batches of extract on the basis either of the responses of the test rats or of the estrous behavior of the experimental ewes failed to show anything which was definitely related to fertility, possible differences in the preparation of the different batches were also investigated. A preliminary examination of the data suggested that the "lot" of trypsin used in preparing a batch of the extract might be associated with the potential fertilizability of the eggs ovulated under its influence. In further trials in 1942–43 only 5 of 36 eggs from two ewes treated with 313WS were fertilized. However, 24 fertilized eggs were found in a total

* A modification of the analysis of variance technique, for enumeration data in which the numbers within classes are not equal, adapted by Dr. A. B. Chapman, Dept. of Genetics, Univ. of Wis.

of 27 recovered from two ewes treated with a new batch of extract (500018) prepared with the same lot of trypsin used to prepare 313WS. This makes it seem doubtful if the differences can be ascribed to the lot of trypsin, but the additional data further characterize 313WS and intensify the belief that there are batch differences in the extract.

One of many possible suggestions to explain the differences which were noted might rest upon slight differences in speed of action or availability of the hormone in different batches. This could result in some eggs being ovulated earlier than others and thus conceivably there could be differences in ripeness of the eggs at the time for fertilization, or even earlier, at the time of ovulation.

Luteal and Anestrous Ewes

In 1941, five ewes were treated in the luteal phase of the estrous cycle using follicle-stimulating extract (311WS), which was known to give fertility in follicular ewes, for the subcutaneous injections. An average of 11.4 fresh corpora lutea was observed, and an average of 5.0 eggs, all unfertilized, was recovered (Table 2).

Five anestrous ewes were treated after the end of the 1940 breeding season using follicle-stimulating extract, 505WS, for the subcutaneous injections. An average of 10.2 corpora lutea was found, and an average of 3.2 eggs, all unfertilized, was recovered. No. 505WS was known to give fertility in the treatment of follicular ewes. (The animals are not included in this study as they were examined 21–36 days after treatment and still had a larger than normal number of embryos.)

In May and June of the second year four anestrous ewes were treated as described for the 1941 work except that 316LS was used and three of them received five rather than four subcutaneous injections. The average number of corpora lutea was 8.2, while an average of 2.2 unfertilized eggs was found. No. 316LS had not been tested on follicular ewes, so the possibility that the batch was at fault here cannot be completely excluded.

In addition to the ewes described above, four anestrous ewes were treated with pregnant mare serum. All four ewes received a single injection of 400 i. u. (5 cc.) of the pregnant mare serum followed 72 hours later in two cases (Nos. 48 and 59) by intravenous injections of one gram-equivalent of unfractionated pituitary extract, while the other two ewes (Nos. 68 and 73) received no further treatment. At autopsy the first two animals were found to have 2 and 4 corpora lutea respectively, and corresponding numbers of eggs, all unfertilized, were recovered. A single corpus luteum was found in each of the latter two ewes, and a single egg, fertilized in one case and not in the other, was recovered from each.

TABLE 2. POTENTIAL FERTILITY OF ARTIFICIALLY MATURED OVA IN LUTEAL EWES, 1941

Ewe no.	Extract no.	No. C.L. in ovaries	Normal embryos recovered	Unfert. eggs or abnormal embryos recovered
50	FSH311WS	16	0	8 unfert.
54	FSH311WS	8	0	3 unfert.
56	FSH311WS	22	0	10 unfert.
58	FSH311WS	1	0	1 unfert.
75	FSH311WS	10	0	3 unfert.
	Ave.	11.4	0	5

TABLE 3. POTENTIAL FERTILITY OF ARTIFICIALLY MATURED OVA IN ANESTROUS EWES

Ewe no.	Extract no.	No. C.L. in ovaries	Normal embryos recovered	Unfert. eggs or abnormal embryos recovered
		1940 season, FSH		
16	FSH505WS	9	0	6 unfert.
7	FSH505WS	14	0	3 unfert.
27	FSH505WS	3	0	2 unfert.
37	FSH505WS	6	0	2 unfert.
39	FSH505WS	19	0	3 unfert.
	Ave.	10.2	0	3.2
		1941 season, FSH		
42	FSH316LS	7	0	1 unfert.
46	FSH316LS	8	0	4 unfert.
70	FSH316LS	7	0	1 unfert.
71	FSH316LS	11	0	3 unfert.
	Ave.	8.2	0	2.2
		1941 season, PMS		
48	PMS116HPAB	2	0	2 unfert.
59	PMS116HPAB	4	0	4 unfert.
68*	PMS116HPAB	1	0	1 unfert.
73*	PMS116HPAB	1	1 (8-cell)	0 unfert.
	Ave.	2	0.25	1.75

* The intravenous injection of unfractionated pituitary extract was omitted in the treatment of these ewes.

The reasons for the lack of fertility in most of the luteal and anestrous ewes are not known. Only one of them (No. 37 anestrous) developed behavioral estrus. It has been stated by Polovtzova and Judovitch (1939) and Lopyrin and Loginova (1939) that the cervix is usually impassible to sperm if ovulation is induced without heat. However, one ewe, No. 73, showed fertility without heat. This, along with the fact that Schott and Phillips (1941) and Green and Winters (1935) found that sperm ascend the oviduct in about the same length of time regardless of the stage of the cycle, leads us to doubt if this interpretation is correct. In an effort to check on this point, the flushings from the oviducts of most of these ewes were examined for the presence of sperm. In only one case were any found, but it is not known whether more could be expected after the interval of two days from last insemination.

The writers (unpublished data) have also observed a lack of fertility in rabbits treated with pituitary extracts while pseudopregnant. These have been autopsied one day after insemination, and in most cases sperm have been found in the oviducts. Assuming that the sperm were potentially fertile when they reached the oviduct, the failure of fertility would appear to be inherent in the eggs and in some way brought about by the reproductive state of the animal at the time of treatment.

That the physiological state of the animal may have affected the reactions of the follicles in the ewes, if not the ova, is shown in the egg recovery. There were significant differences in the number of eggs recovered in relation to corpora lutea number in the three groups of ewes—the proportion of corpora lutea represented by eggs being lower in the luteal and anestrous groups. This variation is interpreted as reflecting, in part at least, the proportions of corpora lutea which may have formed with entrapped ova. If this is the case, it may be that greater "luteinizing" action was exhibited in these animals and this action in turn affected the fertilizability of the eggs produced under its influence.

Summary

Twenty-four "follicular" ewes (12 days after beginning of estrus) treated with follicle-stimulating extracts had a total of 576 corpora lutea and yielded 357 eggs. Seven animals had no fertilized eggs, while 17 others had from 2 to 19 each with a total of 153.

Five "luteal" ewes (3 days after beginning of estrus) treated with follicle-stimulating extracts had 57 corpora lutea but only 25 eggs; none of the eggs were fertilized.

Nine anestrous ewes treated with follicle-stimulating extracts had 84 corpora lutea and 25 unfertilized eggs. Four other anestrous ewes treated

either with pregnant mare serum or a combination of pregnant mare serum and unfractionated pituitary extract had 8 corpora lutea and 8 eggs. Only one of these eggs was fertilized.

Within the follicular ewes there were significant differences in the ability of different "batches" of follicle-stimulating extract to produce potentially fertile eggs. Likewise, there were significant differences between ewes that were treated alike to produce potentially fertile eggs. These differences are unexplained.

The proportions of corpora lutea represented by recovered eggs were lower in the luteal and anestrous animals than in the follicular animals. It is suggested that this indicates a greater tendency toward entrapment of the ova in the first two groups of ewes.

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SURVIVAL OF MULTIPLE PREGNANCIES INDUCED IN THE EWE FOLLOWING TREATMENT WITH PITUITARY GONADOTROPINS[1]

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SUPEROVULATION, following treatment of female mammals with gonadotropic materials, has been noted by several investigators. Engle (1927, 1931) working with the mouse, and Cole (1937) and Evans and Simpson (1940) with the rat found that treated animals often became pregnant. Pregnancies in their cases were generally marked by a relatively heavy embryonic mortality, although the birth of several litters containing more than the normal number of young was reported.

Casida, Meyer, McShan, and Wisnicky (1943) reported that four of seven cows conceived when treated with gonadotropic extracts of sheep pituitary powder so that superovulation occurred at about the time of an expected natural ovulation. As many as seven normal embryos were recovered on the 32nd day of pregnancy, but the embryos of one of the cows were apparently resorbed between the 50th and 70th days of pregnancy.

Parkes and Hammond (1940) injected ewes with horse pituitary extracts two or three days before the onset of estrus and recovered five normal embryos from one of the ewes at about midterm. Loginova and Lopyrin (1938) and Lopyrin, Loginova and Babicev (1940) have reported the birth of as many as five normal lambs at term following treatment with pregnant mare serum in the latter part of the estrous cycle.

Procedure

The work reported here was done during the fall and winter of 1940–41 with grade native ewes predominantly of medium wool breeding. They were purchased in September of 1940 from farmers near Madison, Wisconsin.

Treatments similar to those used by Casida *et al.* (1943) were used in attempts to produce superovulation in ewes. Some preliminary work (not reported here) was required to determine the necessary dosages and it was found that approximately twice as much hormone was needed per animal as for the cow.

The treatment consisted of four daily subcutaneous injections of follicle-stimulating extract* of sheep pituitary powder followed on the sixth day by

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* Extracts prepared by Dr. W. H. McShan, Dept. of Zoology, Univ. of Wis. Follicle-stimulating extract prepared by the method of McShan and Meyer (1940) and the luteinizing extract by a method developed by McShan (unpub.).

an intravenous injection of luteinizing extract* from the same material. Treatment was initiated twelve days after the beginning of an estrous period and terminated on the seventeenth day—at the time natural heat is normally expected in the ewe. The follicle-stimulating extract presumably brought about the development of a large number of follicles, while the luteinizing material aided in bringing about their ovulation. The periods of follicled growth and ovulation coincided with the times when these processes occur naturally in the ewe, and the treatment may be considered as an augmentation of natural physiological processes.

Different batches of follicle-stimulating hormone had to be used. They differed in their gonadotropic potency as determined by rat assay, so dosages for the ewes were adjusted in attempts to keep them constant on a rat-unit basis. The dosages varied from 30 to 48 gram-equivalents per ewe. All ewes were given 10 gram-equivalents of luteinizing extract.

The ewes were either artificially inseminated or allowed to mate on the day of the intravenous injection, and since it was not definitely known when ovulation occurred, they were also inseminated on the following day. The ewes were laparotomized, the ovaries and uterus removed, and the number and condition of the embryos were studied at the end of various intervals following the intravenous injection.

Results and Discussion

To see whether fertilization was occurring, and to establish the probable number of embryos in which development started, seven ewes were examined 2–5 days following insemination (table 1). Six of these had fertilized eggs. These six had an average of 20.8 corpora lutea, but an average of only 13.2 eggs was recovered. It is not known whether this discrepancy was the result of incomplete egg recovery or whether some of the corpora lutea had formed with entrapped ova. No definite stigmata were apparent on some of the corpora lutea, but in some cases more eggs were recovered than there were corpora lutea with stigmata, so it is apparent that the macroscopic appearance of a corpus luteum even at these early stages of pregnancy is of doubtful usefulness in determining whether or not ovulation has actually occurred. An average of 9.2 eggs was found to be fertilized and developing normally as indicated by regularity of blastomere size and absence of visible fragmentation when examined under the binocular microscope. The degree of development varied considerably, stages from 2 to 16 cells being found even within the same ewe. Possibly some of the embryos in the earlier stages had died but not yet degenerated to the point where fragmentation could be detected, or perhaps there were differences in the time of ovulation and therefore in the length of time the various eggs had developed. Along with

TABLE 1. ARTIFICIALLY INDUCED PREGNANCIES IN THE EWE

Ewe no.	Days from first insemination to observation	No. of corpora lutea in ovaries	Normal embryos recovered	Unfertilized eggs or abnormal embryos recovered
23	2	21	4 (4–8 cell)[1]	3 unfertilized[1]
5	3	4	0	2 unfertilized
28	3	25	13 (2–16 cell)	1 unfertilized
36	4	33	19 (2–16 cell)	4 unfertilized
1	4	12	5 (8–16 cell)	4 (8–16 cell)
11	4	21	12 (3–16 cell)	8 unfertilized
32	5	13	2 (16 cell)	3 unfert. 1 of 16 cell
Ave. for 6 preg.:		20.8	9.2	4.0
26[2]	14	7[2]	0	0
30	15	23[4]	6 (1–6 cm. bl.)	11 fragmented eggs
19	18	20[3]	0	0
35	18	16[4]	0	7 ($\frac{1}{2}$–100 mm. blastocysts)
20[2]	21	28	3 (8 mm.)[5]	2 (5 mm.)
10	21	32	4 (6–8 mm.)	1 (4 mm.)
4	22	13[4]	2 (7–8 mm.)	1 (2 mm.)
12	23	10	5 (5–9 mm.)	1 (4 mm.)
15	24	26	4 (8–11 mm.)	4 (2–4 mm.)
17	27	37	3 (12–16 mm.)	2 (2–7 mm.)
Ave. for 8 preg.:		23.2	3.4	3.6
29[2]	30	26	1 (20 mm.)	11 (1–11 mm.)
6	31	16[2]	0	0
38	33	38	1 (26 mm.)	2 (4–11 mm.)
25	34	10[3]	0	0
9	34	?[3]	0	0
13	35	12	0	1 (1 mm.)
21	36	19	1 (26 mm.)	4 (5–11 mm.)
18	37	28	1 (34 mm.)	1 (4 mm.)
Ave. for 5 preg.:		24.6	0.8	3.8

[1] Only the right oviduct was searched for eggs.
[2] Had been used on previous experiment terminating in laparotomy.
[3] Corpora lutea had regressed.
[4] Part of corpora lutea had regressed.
[5] Straight crown-rump length.

the fertilized eggs there was an average of 4.0, either unfertilized eggs or fragmenting embryos. The important thing about this first group of ewes, regardless of whether or not all the embryos classed as normal were living, is the high initial fertility. Of a total of 81 eggs recovered from the seven ewes, 74 per cent were cleaving and 68 per cent were developing in an ap-

parently normal manner. There is no evidence to indicate that the various batches of follicle-stimulating extract differed in their ability to produce ovulation or that the eggs varied in fertilizability.

An average of only 3.4 normal embryos was found in the eight pregnant ewes of a group of ten examined from 14 to 27 days after insemination (table 1). The eight ewes had an average of 23.2 corpora lutea. No ova were found in any ewe later than 15 days, and those recovered from ewe No. 30 at that time were so badly fragmented that it was impossible to determine whether they had been fertilized. There was, however, an average of 2.2 abnormal embryos, which when considered with the normal ones gave evidence of an initial fertility averaging at least 5.6 fertilized eggs per ewe in this group. The classification of embryos as abnormal, both from this group of ewes and from the following one, was made rather arbitrarily, but it was based largely on the condition of the tissues as compared to obviously living embryos. In almost all cases those classed as normal were found to show approximately the same age-size relationships found in sheep embryos by Cleote (1939). The abnormal embryos were probably dead in all except one case—a 2 millimeter embryo of ewe No. 4. The heart of this embryo was observed beating, but was malformed. This in addition to the relatively small size of the embryo, left no doubt as to its classification.

The third group of ewes is not a discrete one in so far as duration of pregnancy is concerned, but there was so marked a decline in number of normal embryos that these ewes are classed separately. Only five of eight ewes examined at 30 to 37 days were pregnant; no ewe had more than one living embryo and the average number per pregnant ewe was only 0.8. There was an average of 3.8 abnormal embryos which, when considered with the normals, gave evidence of an initial fertility of at least 4.6 fertilized eggs per pregnant ewe.

It is apparent that under the conditions of this experiment, superovulation has been produced rather consistently in ewes, and that the ova are highly fertilizable. Although no control data are available, it seems probable from the observed number of ewes requiring more than one service for conception under normal conditions, that the average initial fertility (74%) is probably as high as would be expected from ova ovulated naturally in the ewe. The corpora lutea numbers of 20.8, 23.2, and 24.6, respectively, in the three groups of ewes, and the presence of degenerating embryos in the ewes of the latter two groups, as well as the fact that in several cases ewes in the different groups were treated concurrently, provide strong presumptive evidence that initial ovulation and fertilization rates in the three groups were comparable.

The severity of the early embryonic mortality is evidenced by the fact

that by the 30th to 37th days of gestation the number of living embryos was far below the average for normal ewes. Although their complete data are not available, our results appear to differ from those reported by Parkes and Hammond (1940), Loginova and Lopyrin (1938), and Lopyrin *et al.* (1940) using other gonadotropic hormone preparations at comparable stages of the estrous cycle. None of these writers mention embryonic mortality, although the latter authors do stress the observation that the number of lambs born did not equal the number of corpora lutea. This was attributed to a failure of fertilization in some cases.

TABLE 2. SURVIVAL OF EMBRYOS TRANSPLANTED FROM TREATED DONOR INTO NORMAL HOST EWES

Donor		Recipient		No. eggs transplanted	Result
Ewe no.	Days after intraven. inj.	Ewe no.	Days after beg. heat		
			1940		
1	4	33	6	2	1 fetus at 33 days
32	5	12	6	2	estrous cycle of 18.5 days
28	3	22	3	5	estrous cycle of 18 days
28	3	34	5	5	estrous cycle of 16 days
			1941		
72	3	52	4	4	estrous cycle of 17 days
83	3	62	4	4	2 fetuses at 46 days
89	3	48	3	4	estrous cycle of 18 days
			Totals	26	3 fetuses

There appear to be two possible causes for this early mortality: (1) the rapid maturation of the follicles may induce abnormalities in the ova which do not interfere with fertilization and early development but do prevent the production of viable young, or (2) the female reproductive tract, either inherently or as a result of the gonadotropic hormone treatment, may be incapable of supporting a large number of embryos. If the latter were due to the gonadotropic hormone treatment it could result from a direct effect on the reproductive system itself, or it could come secondarily from some general effect on the animal.

There is relatively little evidence from these data to indicate which of the possibilities is the more probable. A careful examination* of 43 of the

* The authors wish to acknowledge the assistance of Mr. Baron Barker who performed the detailed examinations of the embryos.

recovered embryos failed in most cases to reveal anatomical abnormalities which would account for the high death rate.

An effort was made to determine if embryos, developing from ova of artificially matured and ovulated follicles would be viable in a normal environment. Fertilized eggs in the 8–16 cell stage were flushed from treated ewes with physiological saline or Locke's solution. By means of a small glass pipette attached to a syringe, they were then injected through the wall and into the lumen of the uterus of a normal host ewe whose uterine horns were exposed by laparotomy.

Two of seven host ewes conceived and three of 26 transplanted embryos were accounted for later (table 2). One pregnant ewe was autopsied 33 days after the transplantation and she had one embryo which was normal in appearance and size. It was intended to allow the other pregnant ewe to go to term, but unfortunately she died at an exploratory laparotomy 46 days after the transplantation. She had two normal embryos.

This transplantation work is inconclusive because of the small percentage of "takes." This may very well have been due, however, to faulty technique. The embryos which did survive long enough to interrupt the estrous cycle of the hosts were evidently normal when observed. No degenerating embryos were found with them as in the treated ewes, so what little evidence there is tends to indicate that a normal uterine environment favors their continued growth.

Summary

Follicle-stimulating and luteinizing extracts of sheep pituitary powder have been used to induce superovulation in 25 ewes. Treatment began the twelfth day of the estrous cycle and terminated five days later at the time of natural estrus. All ewes were mated or artificially inseminated.

The viability of the artificially induced multiple pregnancies was checked by observations on different animals at 2 to 5 days, 14 to 27 days, and 30 to 37 days. The numbers of ewes found to be pregnant at the different intervals were 6 of 7, 8 of 10, and 5 of 8, respectively. An average of 9.2 normal embryos per ewe, representing 70% of the eggs ovulated, was found in the first period, 3.4 in the second period, and 0.8 in the third. Many dead and degenerate embryos were found in the later stages. The corpora lutea numbers of 20.8, 23.2, and 24.6 for the three groups were essentially the same, and it is believed that the initial ovulation and fertilization rates were comparable.

Two possible causes of death are suggested: (1) inadequate uterine environment due either to a direct or an indirect effect of treatment, or (2) abnormalities induced in the ova by the rapid maturation of follicles.

In an attempt to obtain information on the cause of death 26 fertilized ova from treated ewes were transplanted to normal ewes at comparable stages of the estrous cycle. Only three of these survived long enough to interrupt the estrous cycle of the host ewes, but the efficiency of the transplantation technique is unknown, so no conclusion as to their viability is possible.

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DISTILLERS' BY-PRODUCTS IN SWINE RATIONS

1. CREEP-FEEDING AND GROWING-FATTENING RATIONS[1]

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Introduction

Several papers, particularly from Missouri, Wisconsin and Pennsylvania, indicate nutritional inadequacies in rations composed of natural ingredients fed to swine in drylot. Hughes of California has contributed to a knowledge of the water-soluble vitamin requirements in swine nutrition. Dried corn distillers' solubles and corn distillers' dried grains with solubles are known to contain water-soluble vitamins and have been shown to serve as vitamin sources in poultry rations according to reports from Massahcusetts, Wisconsin, Minnesota, Washington and Indiana. This paper describes the feeding of an inadequate swine ration composed of natural ingredients and its enhancement by supplementation with corn distillers' by-products. Previous work at Illinois (unpublished) and at Cornell (Krider, 1942) with pigs in drylot did not indicate any significant advantages from using dried corn distillers' solubles.

Objects

1. To compare a basal ration of ground yellow corn, wheat flour middlings soybean meal, tankage, fish meal, minerals and fortified cod-liver oil with the basal ration supplemented with either six percent of dried corn distillers' solubles or with 12 percent of corn distillers' dried grains with solubles when fed to nursing pigs in a creep.

2. To compare the same rations when fed to pigs from weaning to market weight.

3. To observe the residual effect after weaning, if any, of feeding the basal ration fortified with distillers' by-products as sources of the water-soluble vitamins during the nursing period.

Basal Rations

The basal rations used are presented in table 1. Ration 47, containing 25.75 per cent of crude protein, was fed in a creep to the nursing pigs and continued after weaning in a self-feeder until the pigs weighed 50 pounds.

[1] This investigation was made possible by the donations of funds and products to the University of Illinois by Hiram Walker and Sons, Incorporated, Peoria, Illinois.

[2] Acknowledgment is made to J. L. Gobble and S. W. Terrill for their assistance in conducting the experimental work and to R. H. McDade, Chief Swine Herdsman.

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Ration 50, with a crude protein content of 19.28 per cent, was fed to the pigs from a weight of 50 pounds to 100 pounds, and Ration 53 containing 14.5 per cent crude protein was fed from a weight of 100 pounds until the close of the experiment.

TABLE 1. BASAL RATIONS

Ingredients	Ration 47 Pigs in Creep and weaning to 50 lbs.	Ration 50 Pigs 50 to 100 lbs.	Ration 53 Pigs 100 to 225 lbs.
Ground yellow corn	480	611	857
Wheat flour middlings	120	153	—
Soybean meal	200	118	71
Tankage	140	82	50
Fish meal	60	36	22
Mineral mixture (No. 7)[1]	20	20	20
Fortified cod-liver oil	5	5	5
Total	1,025	1,025	1,025

[1] Ground limestone 200, steamed bone meal 200, and salt 100.

Alfalfa meal was not included as an ingredient, and since this feed has been considered valuable primarily as a source of vitamins A and D, approximately 0.5 per cent of fortified cod-liver oil was added.

The chemical composition and vitamin content of the basal rations are presented in table 2. From the figures for riboflavin, niacin, and pantothenic acid, the average weight of pigs by periods, and the average feed consumption, the intake of the vitamins per 100 pounds of live weight was calculated. On Ration 47, the pigs consumed daily 5.57 milligrams of riboflavin, 44.96 milligrams of niacin and 20.38 milligrams of pantothenic acid per 100 pounds of live weight. Ration 50 was consumed in amounts to furnish 6.10 milligrams of riboflavin, 42.26 milligrams of niacin and 21.16 milligrams of pantothenic acid per 100 pounds of live weight daily, while similar figures for Ration 53 are 3.01 milligrams of riboflavin, 26.60 milligrams of niacin and 12.81 milligrams of pantothenic acid. From the figures on requirements for riboflavin (Hughes, 1940), niacin (Hughes, 1938, 1943) and pantothenic acid (Hughes and Ittner, 1942) for 100 pounds of live weight it cannot be said that the basal rations were deficient in these vitamins. Rations 47 and 50 furnished the three vitamins well in excess of the theoretical minimum requirements while Ration 53 was supplying approximately the theoretical requirements for riboflavin and pantothenic acid with no margin of safety.

TABLE 2. CHEMICAL COMPOSITION AND VITAMIN CONTENT OF THE BASAL RATIONS

	Ration 47	Ration 50	Ration 53
Crude protein, per cent	25.75	19.28	14.50
Fat, per cent	3.18	2.44	4.59[1]
Fiber, per cent	2.58	2.72	2.67[1]
Ash, per cent	6.92	6.27	4.75[1]
Calcium, per cent	1.52	1.35[1]	1.03[1]
Phosphorus, per cent	0.97	.85[1]	.64[1]
Manganese, p.p.m.	21.50	21.50	10.20[1]
Vitamin A, I.U. per lb.	8,178.00[1]	8,574.00[1]	9,314.00[1]
Vitamin D, A.O.A.C. chick units per lb.	886.00[1]	886.00[1]	886.00[1]
Riboflavin,[2] mg. per lb.	1.18	1.18	.77
Niacin,[2] mg. per lb.	9.53	8.17	6.81
Pantothenic acid, mg. per lb.	4.32[1]	4.09[1]	3.28[1]

[1] Estimated from literature or from unpublished Illinois data.

[2] Samples steamed one hour with 0.1N acetic acid, made to volume, and allowed to stand to permit solids to settle. The supernatant liquid was used in the assay of riboflavin according to the method of Snell and Strong (Ind. and Eng. Chem. Anal. Ed. 11: 346, 1939) and in the assay for nicotinic acid according to the method of Snell and Wright (J. Biol. Chem. 139: 675, 1941). These assays were conducted by the Department of Bacteriology, University of Illinois.

Distillers' By-Products Used

1. *Dried Corn Distillers' Solubles.* This product is defined by the American Feed Control officials as "the product obtained by drying semi-solid corn distillers' solubles."

The dried corn distillers' solubles used in this experiment are described by the manufacturer[4] as "prepared from distillers' stillage after the coarse grains have been screened out and the fine suspended solids removed by a unique centrifugal process. This process permits the clarified stillage, containing the water-soluble nutrients derived from the original grains and from the grain-yeast fermentation, to be concentrated in multiple effect vacuum evaporators to a thick syrup, which is then dried on drum dryers and flaked."

2. *Corn Distillers' Dried Grains with Solubles.*[5] This product is defined by the American Feed Control officials as "the dried residue obtained in the manufacture of alcohol and distilled liquors from corn, or from a grain mixture in which corn predominates, and contains the major portion of the condensed screened stillage dried therewith."

The corn distillers' dried grains with solubles[4] used in this experiment are described by the manufacturer as "the dried residue obtained in the manufacture of high-proof alcohol and whiskey from a yeast-fermented grain-malt

[4] Technical service bulletins, Hiram Walker & Sons, Inc.

[5] In this experiment a fat-extracted product was used which is now no longer commercially available.

mash in which corn grain predominates and contains the major portion of the condensed clarified stillage (solubles). It is, therefore, the total dried stillage containing the grain residues, yeast, cells and the solubles of the fermentation."

The vitamin content of the two by-products is given in Table 3. (Bauernfeind, et al., 1944).

TABLE 3. VITAMIN CONTENT OF CORN DISTILLERS' BY-PRODUCTS

Vitamin	Type of Assay	Vitamin Content	
		Dried Corn Distillers' Solubles	Corn Distillers' Dried Grains with Solubles
		Micrograms per gram	*Micrograms per gram*
Thiamin	Chick	6–9	3–4
	Chemical	7–10	3–4
Riboflavin	Chick	25–30	13–15
	Microbiological	15–20	7–10
Pantothenic acid	Microbiological	21–26	10–13
Niacin	Microbiological	140–160	70–90
Pyridoxine	Chick	8–10	—
Biotin	Microbiological	2.0–2.4	1.0–1.2
Choline	Chemical	6000–7000	4000–5000
Folic Acid	Microbiological	4	—
P-aminobenzoic acid	Microbiological	9–10	—

Experimental Procedure

Eighteen sows and litters were divided into three groups according to age, breed and weight of sow, and size of litter. (See table 4.) The nursing pigs of Group 1 received the basal, those of Group 2 received the basal plus six per cent dried corn distillers' solubles, while those of Group 3 received the basal plus 12 per cent of corn distillers' dried grains with solubles. The pig rations were offered in pig-creeps, while the sows were hand-fed a standard lactation ration. (See footnote table 5.) Sows and litters were confined in drylot.

As the pigs of each group were weaned they were divided into two lots, equated for weight, sex, breeding and condition. One lot of each group received the basal, while the second lot received the basal supplemented with one of the distillery by-products. The rations were equated for approximate per cent of crude protein as follows: nursing pigs and up to 50 pounds, 25 per cent crude protein; 50 to 100 pounds, 20 per cent crude protein, and 100 pounds to close of experiment, 15 per cent crude protein.

TABLE 4.—DIVISION OF GROUPS OF PIGS INTO LOTS AND TREATMENTS GIVEN IN 1941 FALL TEST (DRYLOT FEEDING)

A. Farrowing to Weaning[1]	Group 1 (Pigs) Basal		Group 2 (Pigs) Basal+6% dried corn distillers' solubles		Group 3 (Pigs) Basal+12% corn distillers' dried grains with solubles	
B. Weaning to Market[2]	Lot 1 Basal	Lot 2 Basal+6% dried corn distillers' solubles	Lot 3 Basal	Lot 4 Basal+6% dried corn distillers' solubles	Lot 5 Basal	Lot 6 Basal+12% corn distillers' dried garins with solubles

[1] All pigs creep-fed, all sows fed same lactation ration.
[2] All pigs self-fed.

Results and Discussion

1. *Up to Weaning*

The results up to weaning time are presented in table 5. The differences between average daily gains per pig are not large and are of doubtful significance. As all groups of sows gained in weight during the lactation period, liberal feeding was indicated. Conservatism suggests that no important differences between groups were evident up to the time of weaning.

TABLE 5. CREEP-FEEDING DISTILLERS' BY-PRODUCTS TO NURSING PIGS IN DRYLOT. FALL 1941

Ration fed[1]	Basal (Ration 47)	Basal+6% dried corn distillers' solubles (Ration 48)	Basal+12% corn distillers' dried grains with solubles (Ration 49)
Number of pigs started	45	45	51.
Number of pigs died during test	4	7	5
Avg. initial litter age (days)	11.2	8.8	10.3
Avg. gain of sows, lbs.	15.0	23.0	11.0
Avg. initial weight of pigs, lbs.[2]	6.85	5.84	6.35
Avg. final weight of pigs, lbs.	23.21	21.76	24.90
Avg. gain of pigs, lbs.[2]	16.36	15.92	18.55
Avg. daily gain of pigs, lbs.[2]	.37	.35	.40
Avg. daily feed for:			
Sows,[1] lbs.	12.5	9.9	12.8
Litter, lbs.	1.2	1.1	1.7
Total, lbs.	13.7	11.0	14.5

[1] Ration number 12 hand-fed to all sows = ground yellow corn, 830; soybean meal, 40; tankage, 80; alfalfa meal, 40; and minerals, 10.
[2] For the pigs that finished.

2. Growth-Fattening Period

The essential data for the six lots of pigs following weaning are presented in table 6. The relative growth curves of the lots of pigs during the first 18 weeks of the post-weaning period are shown in figure 1. The average daily gains were studied statistically by analysis of variance as described by Snedecor (1938) for groups with unequal numbers.

TABLE 6. FEEDING DISTILLERS' BY-PRODUCTS TO GROWING-FATTENING PIGS FROM WEANING TO MARKET IN DRYLOT, FALL 1941. (ALL PIGS SELF-FED)

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Rations fed	Basal	Basal +6% dried corn distillers' solubles	Basal	Basal +6% dried corn distillers' solubles	Basal	Basal +12% corn distillers' dried grains with solubles
No. of pigs started	21	20	19	19	23	23
No. of pigs died during test	10	7	8	6	10	7
Avg. initial weight, lbs.	24.0	23.5	22.0	22.0	24.5	24.6
Avg. final weight, lbs.	187.0	202.0	188.0	222.0	152.0	197.0
Avg. daily gain, lbs.[1]	1.03	1.08	1.02	1.28	0.75	1.07
Avg. daily feed, lbs.[1]	3.85	4.21	4.19	4.97	3.24	4.51
Feed eaten for 100 pounds gain, lbs.[1]	374.	388.	411.	386.	433.	420.

[1] For the pigs that finished.

a. Inadequacy of the Basal Ration. The inadequacy of the basal ration was shown primarily by the poor performance of Lot 1 which received the basal ration before weaning and after weaning until it became necessary to fortify the ration, and further by the results of Lots 3 and 5 which were changed to the basal ration at weaning time as compared to the performance of their litter mates in Lots 4 and 6 which received a supplemented basal ration throughout both phases of the experiment. At the end of about four weeks the pigs in Lot 1 were in such an unthrifty condition that experienced observers believed all pigs would die if continued on the basal ration. Their litter mates in Lot 2 received the supplemented basal ration after weaning, and 13 of them completed the feeding trial with an average daily gain per pig of 1.08 pounds. The pigs of Lots 4 and 6 which received the supplemented basal ration throughout made faster daily gains and suffered lower death

losses than comparable pigs in Lots 3 and 5 which were changed to the basal ration at weaning time.

Other workers have found that rations made from commonly used ingredients are often inadequate for swine when fed in drylot. (Hogan, Johnson and Gahley, 1938) (Hogan and Johnson, 1940, 1941) (Hogan and McRoberts, 1940) Keith *et al.*, 1942) (Ross *et al.*, 1942) (Ellis, Craft and Zeller, 1936) (Ellis and Madsen, 1939, 1941). The basal ration used in the present study appears to be satisfactory in quantity and quality of protein, vitamins A and D, and all minerals with the possible exception of manganese. Although analyses and estimates of the manganese content of the rations indicate that this material may be low, the work of Johnson (1940, 1943) suggests that the basal rations contained enough manganese for satisfactory growth. Symptoms in the pigs were not the same as those described by Keith *et al.*, (1942) as representing manganese deficiency.

As previously indicated the basal rations fed to the pigs up to a body weight of 100 pounds supplied the theoretical minimum requirements of nicotinic acid, riboflavin and pantothenic acid. After the pigs reached 100 pounds the basal rations did not furnish an excess of these vitamins, but the theoretical minimums were met for riboflavin and pantothenic acid. However it is significant that the pigs manifested pronounced symptoms and death losses occurred before the 100 pound weight was attained. This indicates one of three possibilities: (a) the methods of vitamin assay for riboflavin, pantothenic acid, and niacin are inadequate, (b) the growing pig requires more of these vitamins than the literature indicates, or (c) the basal ration used is deficient in other known or unknown factors.

The three basal rations were assayed for riboflavin and niacin. The pantothenic acid values of Bauernfeind, Norris, and Heuser (1942) and those presented in table 3 were used in estimating the content of this vitamin in the rations. The possibility exists that the microbiological assay values obtained for riboflavin and pantothenic acid may be high. The recent work of Bauernfeind, Sotier, and Boruff (1942) and of Strong and Carpenter (1942) shows that stimulants exist in certain foodstuffs which induce growth *L. casei* in assays for riboflavin and pantothenic acid when suboptimum amounts of these vitamins are present in the assay medium. Neal and Strong (1943) report that reliable pantothenic acid assays can only be expected by the *L. casei* method when bound pantothenic acid is suitably liberated and both fat-soluble and water-soluble interfering substances are avoided. Modifications of the microbiological method for the determination of niacin have been suggested by Krehl, Strong and Elvehjem (1943) and Garey, Bauernfeind and Boruff (1943).

b. Supplemental Effects of the Distillers' By-Products. Krider (1942) work-

ing with 50-pound growing-fattening pigs, supplemented a basal ration of ground yellow corn, standard wheat middlings, tankage, linseed meal and 0.125 per cent fortified cod-liver oil with dried corn distillers' solubles. The supplemented ration increased the average daily gain per pig 0.07 pound, but "did not improve the thrift of the pigs or prevent abnormal conditions."

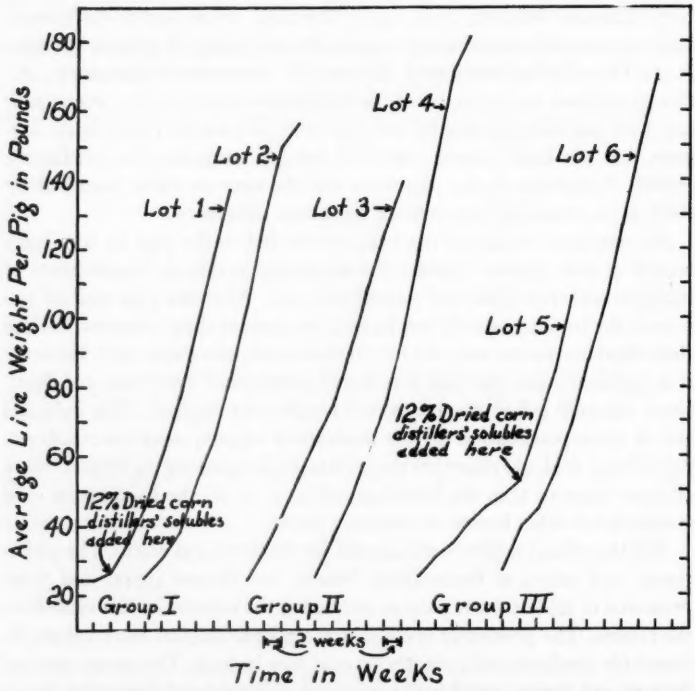

Figure 1. Growth curves of groups of growing and fattening pigs fed the basal, the basal plus dried corn distillers' solubles, and the basal plus corn distillers' dried grains with solubles.

The Illinois Station (unpublished data) employed two basal rations, namely, ground yellow corn, tankage, minerals and cod-liver oil and ground corn, soybean meal, minerals and cod-liver oil. When these two rations were fed to pigs weighing 75 pounds in drylot and compared with the basal mixtures supplemented with dried corn distillers' solubles no significant differences were noted. The pigs used in the above tests, however, were on pasture prior to the initiation of the experiments and were heavier than those used

in this experiment. The previous treatment of pigs may well be an important factor in their subsequent behavior when they are placed on test in drylot. This suggestion is supported by evidence in this paper.

The growth curves of Lots 1 and 5 (figure 1) and the results of Lots 2, 4, and 6 when compared with Lots 1, 3, and 5 (table 6 and figure 1) indicate the supplemental effect of nutrients supplied in the distillers' by-products.

To the basal ration fed Lot 1, 12 per cent dried corn distillers' solubles were added at approximately the fourth week following weaning, as indicated by the arrow in figure 1. Almost immediately the pigs began consuming more feed with a consequent marked increase in gains. This could have been due either to palatability, to the change of feed, or to the addition of factors which were deficient in the basal diet.

The pigs of Lot 5 received the basal ration supplemented with 12 per cent of corn distillers' dried grains with solubles until weaning, after which they were fed the basal ration. They were able to subsist for 12 weeks on the basal ration, and then it was deemed advisable to supplement their ration with 12 per cent of dried corn distillers' solubles, as the performance of the pigs was unsatisfactory. The time of this addition to Lot 5 is indicated by the arrow in figure 1 and the shape of the curve indicates the response. The shape of the growth curves of Lots 1 and 5 following the supplementation becomes an essential part of the data, but the heights of the growth curves must not be compared with those for the other lots, unless consideration is given to the fortification. Also the fact that 10 pigs died in each of these lots must be considered because the growth curves are for those pigs that survived.

The pigs of Lots 2, 4, and 6 received a supplemented basal ration following weaning while their litter mates in Lots 1, 3, and 5 were fed the basal ration only, unless necessity indicated supplementation later on (See table 6 and figure 1). The death losses were lower in Lots 2, 4, and 6 and the average daily gains of the pigs were greater than the gains of their litter mates in Lots 1, 3, and 5. The average daily gain per pig in Lot 4 was 0.26 pound more than the average daily gain per pig in Lot 3. This difference was statistically significant. Since it was necessary to supplement the rations of Lots 1 and 5, it is not possible to make similar comparisons between Lots 1 and 2 and Lots 5 and 6. Yet the data for these lots in table 6 and the growth curves in figure 1 are of interest and indicative of deficiencies in the basal ration.

c. Comparison of Dried Corn Distillers' Solubles and Corn Distillers' Dried Grains with Solubles. Dried corn distillers' solubles fed at the six per cent level after weaning (Lot 4, table 6) was superior to corn distillers' dried

grains with solubles fed at the 12 per cent level (Lot 6, table 6). The average daily gains were 1.28 and 1.07 pounds, and the difference is statistically significant. A comparison of the results of Lots 3 and 5 further attest to the superiority of the dried corn distillers' solubles. The pigs of Lot 3 were fed the basal ration plus six per cent dried corn distillers' solubles before weaning and the basal ration after weaning, while Lot 5 received the basal ration plus 12 per cent corn distillers' dried grains with solubles before weaning and the basal ration after weaning. The pigs in Lot 3 continued to survive on the basal ration after weaning with no greater death losses than were experienced in the other lots, while the pigs in Lot 5 grew at such a slow rate after weaning that additional fortification was necessary for survival after the twelfth week.

d. Residual Effects. The pigs of Lot 1 received the basal ration before weaning while those of Lots 3 and 5 were fed a supplemented basal ration before weaning and the basal ration without supplement after weaning. These data indicate a residual effect. The pigs of Lot 3 which received the basal ration plus six per cent of dried corn distillers' solubles before weaning were able to survive on the basal ration after weaning, while those of Lot 1 which had received only the basal ration had to be fed a supplement in addition to the basal ration approximately four weeks after weaning. While the data for Lots 3 and 5 show no significant differences at weaning, the pigs fed the dried corn distillers' solubles in the creep manifested a greater so-called residual effect than the pigs fed the corn distillers' dried grains with solubles, as the latter showed evidence of serious malnutrition within 12 weeks after weaning. The superior results of Lot 4 over Lot 2 further indicate the residual effect.

In as much as all the rations contained fortified cod-liver oil to supply vitamins A and D, the evidence is interpreted to indicate that pigs do have limited capacity to store certain water-soluble vitamins and possibly other needed factors. The first few weeks after weaning are critical ones in the life of the young pig. Some fortification of the pig's ration during the suckling period or immediately after weaning, or both, seems advantageous under the conditions of this experiment.

e. Death Losses. The death losses were highest in Lots 1, 3, and 5, which were fed the basal ration after weaning. The uncommonly high death losses were probably due in part to persistent scouring in all lots throughout a major part of the experiment, but were independent of nutritional status. Post-mortem examinations indicated involvement of the alimentary tract.

Summary and Conclusions

Studies were made with 18 litters of fall-farrowed creep-fed pigs. A basal ration of ground yellow corn, wheat flour middlings, soybean meal, tankage

fish meal, minerals and fortified cod-liver oil was compared with the basal ration plus six per cent of dried corn distillers' solubles and with the basal ration plus 12 per cent of corn distillers' dried grains with solubles. Up to weaning no significant differences were noted.

When rations containing the same ingredients were fed to pigs after weaning, the pigs failed to thrive normally, thus confirming the observations of other investigators that drylot rations commonly fed are nutritionally inadequate in factors other than protein, minerals, and vitamins A and D. The basal ration appeared to be adequate in quantity and quality of protein and in minerals. With 0.5 per cent of fortified cod-liver oil in the basal, vitamins A and D were not lacking. Assay values for riboflavin, niacin,and pantothenic acid indicated that the basal ration supplied more than the minimum requirements for pigs weighing 100 pounds or less. Available evidence would not lead one to suspect a deficiency of vitamins B_1 (Hughes, 1940a) and B_6 (Hughes and Squibb, 1942) in the basal ration. If the basal ration was not deficient in riboflavin, niacin, and pantothenic acid, as indicated by present knowledge, the possibility then exists that other factors known or unknown required by the pig may exist and were supplied by the distillers' by-products.

The addition of either six per cent of dried corn distillers' solubles or 12 per cent of corn distillers' dried grains with solubles contributed to the nutritive qualities of the basal rations. Both of these feeds are sources of the water-soluble vitamins.

Dried corn distillers' solubles were superior to corn distillers' dried grains with solubles as a supplement to the basal ration.

The pigs which were fed the fortified rations up to weaning and then changed to the basal, manifested a so-called residual effect. Since the vitamin A and D content of the rations was about the same, at least a part of this effect must be attributed to the ability of pigs to store certain water-soluble factors for future use.

The high death losses were probably due in part to persistent scouring in all lots throughout a major portion of the test period. Post-mortem examinations indicated involvement of the alimentary tract, but the data do not justify any conclusive statement in regard to the association of nutritional status and death losses.

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THE INFLUENCE OF SEASONAL DIFFERENCES ON THE GROWTH OF NAVAJO LAMBS

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Introduction

GROWTH in lambs raised on the range is directly related to the amount and quality of forage available for their consumption. The amount and quality of range forage is in turn governed to a large degree by weather conditions which vary from year to year. Consequently, as pointed out by Phillips, Stoehr, and Brier (1940), differences in rates of growth between seasons are inevitable when animals are raised on the range where feed is dependent upon weather conditions. So far as can be ascertained, however, the extent of these seasonal variations has not been determined heretofore for range sheep. The object of the present paper, therefore, is to show the extent that growth in Navajo lambs, as measured by increases in live weight, is influenced by differences between seasons.

Materials and Methods

The work was done at the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico. In this study all lambs born during the two middle weeks of May, each year from 1938-1941, have been used. These two weeks were chosen because the majority of lambs were born during this time, making it possible to secure a sample with a minimum spread in age sufficiently large to be representative of the entire lamb crop.

Throughout the study the management of the flock and the method of securing the weights have been held as constant as possible. The weight of each lamb was secured on the range as soon as possible after birth. The next weight was taken four weeks after the mean birth date of the lambs under study. Subsequent weights were taken at intervals of four weeks.

On the day weights were to be secured the sheep were trailed directly from the bed-ground to the weighing corral. This distance was usually not over 1½ miles and they were at the corral by eight o'clock in the morning. Since all the lambs to be weighed were branded it was a simple task to cut them into a holding pen. From this pen the lambs were caught at random and weighed on a direct reading platform scale. The entire cutting and weighing operation was completed in about 2½ hours.

[1] This study was conducted at the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, N. Mex., under authority of the Bankhead-Jones Act, in cooperation with the Bureau of Indian Affairs, United States Department of the Interior.

TABLE 1.—NUMBER, MEAN WEIGHTS, AND STANDARD DEVIATIONS FOR EACH AGE OF LAMBS WEIGHED, 1938–1941

Year	Lambs	Age											
		Birth		4 weeks		8 weeks		12 weeks		16 weeks*		20 weeks	
		Weight	S.D.	Weight	S.D.	Weight	S.D.	Weight	S.D.	Weight	S.D.	Weight	S.D.
	number	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
1938	211	7.8	1.3	23.1	4.1	34.3	6.4	43.9	8.2	51.8	8.9	58.8	9.4
1939	279	8.1	1.3	22.1	4.1	32.5	6.1	42.0	7.6	49.0	6.8	55.8	7.0
1940	162	7.7	1.3	20.5	4.3	31.3	6.6	44.4	8.0	—	—	56.2	8.8
1941	87	7.9	1.3	24.3	4.7	38.6	6.3	51.0	7.9	59.0	8.4	65.2	8.2
Total or Average	739	7.9	1.3	22.3	4.4	33.5	6.7	44.1	8.3	51.5	8.6	57.9	8.8

* No weight secured for this age in 1940.

Description of the Range

The Fort Wingate range area lies just West of the Continental Divide on the North Slope of the Zuni mountains and has an elevational range of from 6,800 to 7,500 feet. The vegetative cover, which is typical of the higher elevations in northern New Mexico and Arizona, is generally classified as Piñon-Juniper or Woodland type. More specifically the range may be broken into two broad vegetative types: (1) the Grassland-Browse type, which covers the lower portion of the area, and (2) the Piñon-Juniper type which covers the balance of the area.

The Grassland-Browse type topographically presents an open vista of low rolling hills and broad valleys. The Pinion-Juniper type of range is characterized by densely timbered steep slopes and high plateaus with occasional small, open park-like valleys. Except for these small valleys range of this type has a vegetative cover of comparatively low palatability.

The estimated carrying capacity of the entire area is about 25 sheep per section per year. Portions of the Grassland-Browse type, however, will easily carry double that rate of stocking.

Data and Discussion

In the following presentation of data and discussion the lambs weighed each year have been considered as a group. Since the object of this paper is to show the extent that growth in Navajo lambs is influenced by differences between seasons, rather than a detailed analsyis of the growth of these lambs, it has not been considered necessary to deal with the sexes and birth types separately.

The number of lambs which have been used in this study, together with the mean weights and standard deviations for the several ages, are given in table 1. Although the actual number of lambs weighed varies from year to year, approximately 50 per cent of the lambs born each year have been used.

From table 1 it is seen that only slight differences between the mean birth weights for the four years were found and the standard deviations were all of the same size. From four weeks to 20 weeks of age, however, the differences betseen the mean weights were larger than those present at birth. As the lambs became older and increased in weight greater differences were also found between the weights of individual lambs. The increased variability of the weights is shown by the increased size of the standard deviations of the weights for the older ages. The results of analyses of variance which were carried out on these data showed that the differences between the mean birth weights were not significant, while the differences between the mean weights at 4, 8, 12, 16, and 20 weeks of age were highly significant.

Additional information was furnished by the offspring of six rams. These rams were used for breeding in 1938 and 1939 and were mated to a number of the same ewes each year as well as to a number of different ewes. The matings resulted in 42 lambs having the same sires and dams and 117 lambs having the same sires but different dams. For lambs having the same sires and dams an analysis of variance showed no significant differences between the mean weights at birth, 4, and 12 weeks of age, but at 8, 16, and 20 weeks of age significant differences between the mean weights were found. The analysis of variance of the weights for lambs having the same sires but different dams showed significant differences between the mean weights for 1938 and 1939 at all ages except birth. The number of animals used in these comparisons

TABLE 2.—PER CENT OF TOTAL VARIANCE ATTRIBUTED TO BETWEEN AND WITHIN YEAR SOURCES OF VARIATION

Group of lambs	Source of variation	Age					
		Birth	4 Weeks	8 Weeks	12 Weeks	16 Weeks	20 Weeks
			per cent	*per cent*	*per cent*	*per cent*	*per cent*
All lambs	Between years	—*	92.3	89.9	89.8	84.4	88.9
	Within years	—	6.8	10.1	10.2	15.6	11.1
Lambs with same sires & dams	Between years	—	—	89.8	—	81.3	87.3
	Within years	—	—	10.2	—	18.7	12.7
Lambs with same sires & different dams	Between years	—	87.1	65.7	90.2	87.7	68.6
	Within years	—	12.9	34.3	9.8	12.3	31.4

* No percentages calculated where insignificant differences between the mean squares occurred.

was, of course, small, but the results were in line with those secured for the whole population.

The analyses of variance which were carried out for the data contained in table 1, as well as those carried out for the two selected groups of lambs, were used to calculate the relative importance of differences between years in causing variations in weight. These results are presented in table 2 where the per cent of the total variance which could be attributed to differences between and within years has been calculated according to the method of Chapman and Lush (1932). In the table no percentages were calculated where insignificant differences between the mean weights were found. From table 2 it is seen that where significant differences between the mean weights occurred the portion of variance attributed to differences between years was responsible for most of the variation in the mean weights for each

of the three groups of lambs. The table also shows that while the percentages for the two groups of lambs having either the same sires and dams or the same sires and different dams covered a slightly greater range than was found for the whole population, the percentages were of the same general magnitude as the percentages obtained when the whole population was considered.

It was assumed that, because of the close agreement between the two select groups of lambs and the whole population, genetic factors were not so important in causing the differences in weights observed between the years as were uncontrollable environmental factors. The manner in which the breeding pens were made up has strengthened this assumption. One ram was mated with all the ewes in a breeding pen, and with few exceptions an entirely new group of rams was used each year. As a result of these shifts in breeding pen assignment very little inbreeding has been done. Another factor that reduced the importance of genetic agencies which might have caused differences in weights between the years was the basis of selection and pen assignment of the animals. The sheep were selected and assigned to a breeding pen solely on the basis of their fleece type. In these selections attention was paid neither to the lamb production records of the various pens nor to the records of the individuals. Thus there has been no conscious selection either for or against factors which would result in progressive year to year increases or decreases in rates of growth and consequently weights at given ages.

Further evidence supporting the assumption that genetic factors were of minor importance in causing differences in weight between the years was furnished by testing the homogeneity of the variance of the mean weights. The homogeneity of the variance of the mean weights for each year at the different ages was tested by means of chi-square, using Bartlett's (1937) test as given by Rider (1939). Although there were highly significant differences between the mean weights at all ages except birth, the chi-square test showed no difference between the variances except at 16 and 20 weeks of age.

The chief reason for the significant differences found between the variances at 16 and 20 weeks of age probably was the early weaning of the ram lambs. As the ram lambs became sexually mature they had to be removed from the ewe and lamb band. Usually they showed a loss in weight for a short time after separation.

This early weaning of the ram lambs each year has favored the ewe lambs for they have been left with their dams. The 20 week weight has been taken as an arbitrary weaning weight; actually, however, some of the ewe lambs were still nursing at the time the ewes were bred in December.

TABLE 3.—ANNUAL PRECIPITATION RECORDS, 1938–1941

Year	Month												Total for year
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
	inches	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*	*inches*
Average 1864–1911	0.95	1.42	1.02	0.98	0.58	0.69	2.34	2.31	1.37	1.05	0.76	0.97	14.45
1938	.52	.79	1.95	.43	.61	1.67	.78	1.84	.87	.10	.67	.24	10.47
1939	1.96	.62	.64	1.57	.29	Tr.	.85	1.23	1.31	.30	.10	1.22	10.09
1940	.76	.53	.59	.53	.61	1.00	.48	1.92	2.05	2.15	.89	2.14	13.65
1941	.89	1.12	1.80	1.46	2.10	.76	.71	1.75	4.05	2.40	.73	.70	18.47

The agreement between the live weights of the lambs given in table 1 and the precipitation for the same period supports the previous assumption that uncontrollable environmental factors were responsible for most of the differences in weight observed between the years. This relation can best be shown by comparing the amount of moisture received during the years under study with the 47-year average obtained from precipitation records that were kept by the United States Army at Fort Wingate from 1864 to 1911. The monthly precipitation records are given in table 3. The table shows an average of 14.45 inches of moisture per annum for the 47-year period. The first three of the four years under consideration in this study were below the 47-year average in the amount of moisture received. The fourth year was above the 47-year average. Assuming the 47-year average to be normal (100 per cent) for this region, 1938 had 72.5 per cent normal precipitation. Only 69.8 per cent of the normal amount of moisture was received in 1939. In 1940 the precipitation was nearer normal, being 94.5 per cent, while in 1941 precipitation was 127.9 per cent normal.

The time of precipitation as well as the total amount of moisture received during the year must be taken into account in any evaluation of conditions which affect the range. It is generally believed by livestock producers in this region that the precipitation received from November to April governs to a large degree the amount and quality of spring and early summer forage, while the rain received from April to October governs the amount of forage available for late summer, fall, and winter use.

Drouth conditions prevailed in 1938, 1939, and through the summer of 1940, for in addition to being deficient in total moisture, the moisture was received at times when only part of its value could be realized. In 1939 the feed on the range was much poorer than it was for the previous year for in addition to approximately a 30 per cent deficiency in total moisture, following an almost equally dry year, only scattered showers fell from early May until late August. The dry summer period resulted in almost complete desiccation of the early plants and extended beyond the time when the late grasses and browse could make normal growth. As a result of the scarcity of feed the lambs weighed in 1939 were lighter than those weighed in 1938.

The situation became so acute in the summer of 1940 that it was necessary to lease outside range in July, August, and September. The leased range was in the higher Zuni mountains (7,500 to 9,000 feet elevation) about 35 miles east of the laboratory. It had a carrying capacity easily double that of the laboratory range. Although the sheep were moved away from headquarters the latter part of June, many of the lambs had already received a definite check in growth. This check was more apparent in the general appearance of the lambs than is shown by the weights in table 1; they lost the

appearance of thrift and bloom which is characteristic of healthy, rapidly growing lambs.

The three year drouth ended in the fall of 1940; over five inches of moisture were received during the months of October, November, and December. Above normal moisture was received throughout the winter, spring, and summer of 1941. For the first time during the course of this study the range remained green throughout the summer.

It was again necessary to lease range in the summer of 1941, not because of lack of feed on the laboratory area, but because most of the summer range at headquarters was taken over for National Defense uses. In early June the sheep were moved to the same range they had occupied in the summer of 1940.

The lambs weighed in 1941 averaged heavier from 4 to 20 weeks of age than the lambs weighed in previous years. The differences between the mean weights became more pronounced as the lambs grew older. At 20 weeks of age the 1941 lambs were not only heavier but also thriftier than were the lambs of the three previous years. The difference between the lambs weighed in 1941 and those weighed in the preceding years can be attributed directly to the favorable season.

Summary

Groups of Navajo lambs raised at the Southwestern Range and Sheep Breeding Laboratory, Fort Wingate, New Mexico, have been weighed at intervals of four weeks from birth to weaning age (20 weeks) each year from 1938 to 1941, inclusive. The lambs were all born during the two middle weeks of May and had a range of one week on either side of the mean age.

Highly significant differences between the mean weights of the four years were found at all ages except birth. Analyses of variance showed that whenever significant differences between the mean weights occurred, the variance between the years was responsible for most of the variations in weights. Analyses carried out on two select groups of lambs yielded similar results.

The importance of uncontrollable environmental factors was shown by the agreement between the lamb weights and the precipitation received for the same period. It was pointed out that range forage was dependent upon the amount and time of precipitation, and that the amount of forage largely determined the growth made by the lambs. During 1938 to 1940 drouth conditions prevailed, while the amount of moisture received in 1941 was considerably above normal. The lambs weighed in 1941 were not only heavier but they were also thriftier than those weighed in the previous years. These differences were attributed to the favorable season.

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COMPARISON OF GROWTH IN KARAKUL AND MUTTON BREEDS OF SHEEP

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Introduction

ALTHOUGH Karakul sheep are primarily a fur-producing breed, a sizeable percentage of the lambs produced in both purebred and crossbred flocks are inferior in fur quality and are of more value when raised to market age for meat purposes. This means of disposing of the lambs is especially important to breeders who because of the scarcity and high prices of purebred Karakul sheep must depend to a considerable extent upon systems of cross-breeding and grading-up with the more available American breeds for the development of their Karakul flocks. Under these systems marketable lambskins cannot be expected, except for occasional pelts, before the third generation of top-crossing the ewe stock to purebred Karakul rams, regardless of the breed used for foundation stock. The rate at which these early generation lambs grow and the size they attain at 3 to 6 months of age are particularly important since they usually must be marketed in competition with lambs of the mutton breeds.

Some data on the growth of the mutton breeds of sheep, as measured by body weights, have been reported by Foster (1926), Hammond (1932), Phillips and Brier (1940), Phillips and Dawson (1940), and a few other investigators, but attempts to study this phenomenon in Karakul sheep have been extremely limited. O'Brien (1918) states that Karakul lambs are quick maturing and up to 3 months of age will average higher in body weight than mutton sheep; after that age, however, they grow less rapidly. Jahn (1937) is of much the same opinion and indicates that Karakuls are particularly suited for hothouse lambs or for early lamb raising where quick growth is essential. Still others emphasize the fact that no attempts have been made to develop a mutton strain and the lambs cannot be expected to grow and develop as do those of the mutton breeds. In general, there is much diversity of opinion regarding this question. The object of this paper, therefore, is to present growth data on purebred and crossbred Karakul lambs and to compare their gains in body weight with similar data obtained from lambs of the mutton breeds handled under farm flock conditions.

[1] The cooperators in the project dealing with Karakul sheep are D. A. Spencer, J. I. Hardy, R. G. Schott, and C. G. Potts of the Bureau of Animal Industry, United States Department of Agriculture, and F. G. Ashbrook, C. E. Kellogg, and Thora M. Plitt Hardy of the Fish and Wildlife Service, United States Department of the Interior.

Material and Methods

Body weights used in this study were obtained from Karakul lambs and those produced by crossing Corriedale and Blackfaced Highland ewes with purebred Karakul rams at the United States Department of Agriculture, Beltsville Research Center, Beltsville, Md., during the years 1929–1935 and 1937. Body weights on lambs of the Hampshire, Shropshire, Southdown, and Corriedale breeds produced at this same station during the period 1930 to 1935 were used for comparison with the Karakul and Karakul crossbred lambs. The numbers of animals of each breed and sex observed at birth and at 13, 26, and 52 weeks of age are shown in table 1. These data represent only lambs born as singles. Since only about 5 per cent of the births in the purebred Karakul flock yielded twins, the numbers of these lambs remaining after some were pelted were considered as too few to furnish adequate comparisons with lambs from multiple births of the other breeds. The number of Karakul male lambs available for this study was also small since the only ones retained were those of the most superior fur quality needed for breeding stock.

TABLE 1. NUMBER OF ANIMALS AT VARIOUS AGES ON WHICH GROWTH DATA WERE AVAILABLE

Breed	Birth		13 Weeks		26 Weeks		52 Weeks	
	Male	Female	Male	Female	Male	Female	Male	Female
Karakul	13	79	13	79	12	73	11	38
Hampshire	42	44	42	44	40	40	23	27
Shropshire	40	36	40	36	30	27	18	15
Southdown	57	41	56	41	42	37	26	29
Corriedale	35	39	35	39	30	36	15	28
Karakul×Corriedale	0	30	0	29	0	26	0	19
Karakul×Blackfaced Highland	0	37	0	35	0	29	0	25

During the period 1929–1935 all female Karakul lambs were kept for breeding purposes in an effort to increase the size of the flock as rapidly as possible. All Karakul lambs born in 1936 were pelted for their fur, consequently this period is not represented in the study. By 1937 the Karakul flock had become sufficiently large to permit elimination of those female lambs having fur of inferior quality, a practice which was followed without regard to any other breeding or production factors.

All male lambs from the Karakul-Corriedale and the Karakul-Blackfaced Highland crossbred lines were pelted for experimental fur studies. Therefore, growth data representing only the female crossbred lambs are pre-

sented. Because of the availability of a larger number of second and third top-cross females, these were used for comparison with the purebred Karakul and the mutton breeds. The growth data for the second and third top-cross lambs within each crossbred line were similar and were combined to provide a more adequate sample for comparison of the growth between the two crossbred lines.

The numbers of lambs of the mutton breeds available for study from birth to 13 weeks of age were not affected by elimination from other than natural causes, while those weights taken at 26 and 52 weeks, especially the latter, were on animals somewhat affected by selection. The flocks were culled about August 15 and again about November 15 and those lambs that appeared to be superior in mutton form, growth rate, fleece, and breed type were retained for breeding purposes.

The flocks of each breed were handled in a similar manner and comparable with the established farm practices used in the management of sheep. Use was made of temporary and permanent pasture crops in the summer and barn feeding was practiced during the winter months. The temporary pasture crops were principally seedings of wheat, rye, or barley or mixtures of these for late fall and early spring grazing, followed by seedings of oats and peas and of soybeans for late spring and summer crops to supplement the mixed grass pastures. Mixtures of corn, oats, wheat bran, and linseed meal provided the concentrates, while alfalfa or clover hay and corn silage were the usual roughages available. The breeding animals were kept in as thrifty condition as possible. All lambs were creep-fed during the suckling period and weaned about August 1.

The lambing season usually extended from late in January to early in May, most of the lambs being born in February and March. Birth weights of the lambs were recorded to the nearest 0.1 pound as soon after birth as possible and never later than 24 hours. Weights of all lambs were then taken to the nearest pound once weekly up to one year of age. The weights at birth, 13, 26, and 52 weeks were used as statistical measures of the relative growth of lambs in the various groups.

Data and Discussion

Growth data are presented graphically in figures 1 and 2. It will be observed that the Karakul lambs of both sexes are definitely smaller than the Hampshire and larger than the Southdown lambs at practically any age from birth to 52 weeks. This is likewise true for Shropshire, Corriedale, and crossbred lambs. Compared with the Shropshire and Corriedale lambs, the Karakal appears to grow fastest and is largest. This is especially true of the Karakul males, the females showing greater similarities in trend of growth.

The growth curves for the crossbred lambs were similar in trend to those representing the Karakul, Corriedale, and Shropshire female lambs. In general, the breeds maintain their same relative positions from birth to 52 weeks.

The average birth weights of the Karakul and Karakul crossbred lambs, especially the females, showed greater similarity to those of the Hampshire than to the lambs of the other mutton breeds. The birth weights of the Kara-

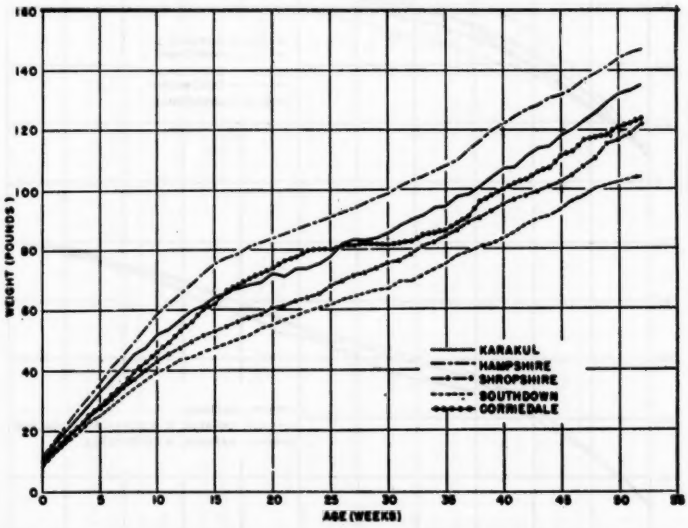

Figure 1. Growth curves of Karakul male lambs and those of mutton breeds from birth to 52 weeks of age. (Curves represent only lambs born as singles.)

kul male lambs ranged from 9.3 to 12.8 and of the females 6.3 to 12.8, averaging 11.1 and 10.2 pounds, respectively. These data are comparable with the results of studies reported by Golf (1933) in which Karakul males from single births had weights ranging from 8.2 to 14.6 pounds, with an average of 11.2 pounds; similarly, the female singles ranged from 7.1 to 13.4 pounds, with an average of 9.3 pounds. Adametz (1914) reports a range of from 7.7 to 11.0 pounds in body weights for Karakul lambs at birth.

Phillips (1936, 1937) and Phillips and Dawson (1940) found that a positive relationship exists between weight at birth and subsequent weights in lambs. Birth weights of lambs in the Hampshire, Shropshire, and Southdown breeds were reported to have a definite relationship to weight at 3

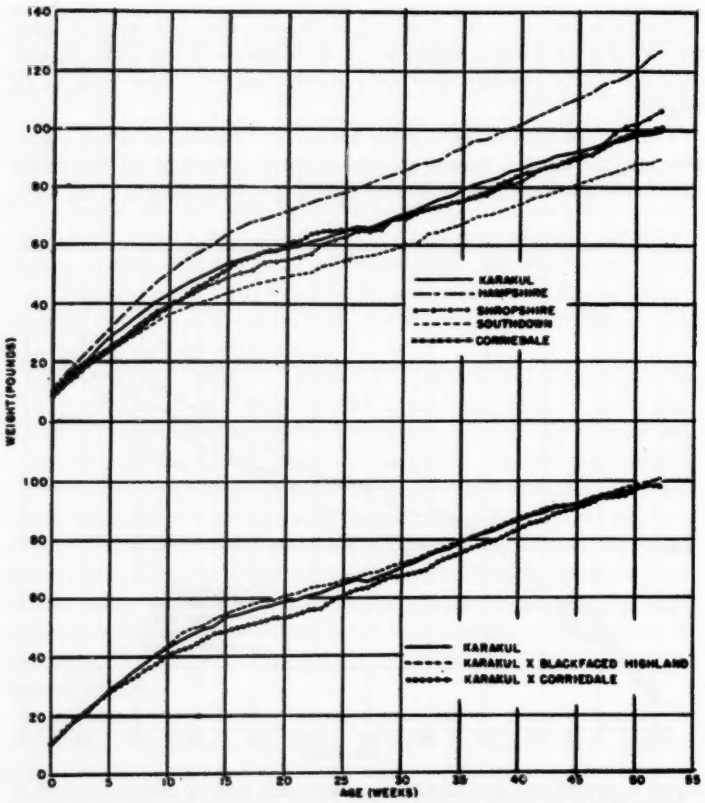

Figure 2. (Upper). Growth curves of Karakul female lambs and those of mutton breeds from birth to 52 weeks of age. (Lower). Growth curves of purebred and crossbred Karakul female lambs from birth to 52 weeks of age. (Curves represent only lambs born as singles.)

months and a less marked effect at later ages. In view of these relationships and the differences in average birth weights between breeds, it is apparent that a more valid comparison of the breed differences in rate of growth would be given by removal of the effect of differences in birth weights. Table 2 presents data showing the results of a statistical analysis of the mean gains in body weights of the Karakuls and of the lambs of the mutton breeds. With these breeds the differences in mean gains have been tested for significance on both an adjusted and unadjusted birth weight basis. Three growth periods were studied, from birth to 13, 26, and 52 weeks, and the

TABLE 2. COMPARISON OF GAINS IN BODY WEIGHT OF KARAKUL LAMBS WITH THOSE MADE BY MUTTON BREEDS OF SHEEP FROM BIRTH TO 13, 26, AND 52 WEEKS OF AGE.[1]

Breed	Sex	Gain to 13 weeks				Gain to 26 weeks				Gain to 52 weeks			
		Mean	Difference from Karakul	Significance of differences		Mean	Difference from Karakul	Significance of differences		Mean	Difference from Karakul	Significance of differences	
				Unadjusted	Adjusted for birth weight			Unadjusted	Adjusted for birth weight			Unadjusted	Adjusted for birth weight
		pounds	*pounds*	*P values*	*P values*	*pounds*	*pounds*	*P values*	*P values*	*pounds*	*pounds*	*P values*	*P values*
Karakul	Male	48.5				71.0				123.8			
	Female	39.5				56.5				88.6			
Hampshire	Male	56.6	+ 8.1	<0.01	0.02	80.2	+ 9.2	0.04	0.07	134.4	+10.6	0.14	0.19
	Female	48.2	+ 8.7	<0.01	<0.01	69.7	+13.2	<0.01	<0.01	116.9	+28.3	<0.01	<0.01
Shropshire	Male	39.9	− 8.6	<0.01	<0.01	60.1	−10.9	<0.01	0.02	111.5	−12.3	0.08	0.07
	Female	36.9	− 2.6	0.16	0.11	56.4	− 0.1	>0.90	0.16	97.8	+ 9.2	0.06	0.08
Southdown	Male	35.6	−12.9	<0.01	0.04	55.0	−16.0	<0.01	0.24	95.4	−28.4	<0.01	0.02
	Female	33.1	− 6.4	<0.01	0.16	48.3	− 8.2	<0.01	0.18	81.9	− 6.7	0.02	0.28
Corriedale	Male	46.6	− 1.9	0.51	0.24	72.0	+ 1.0	0.83	0.09	113.7	−10.1	0.19	0.17
	Female	38.2	− 1.3	0.47	0.18	57.9	+ 1.4	0.53	0.26	92.4	+ 3.8	0.34	0.28

[1] Table includes only lambs born as singles.

data were analyzed by the method of covariance described by Snedecor (1937). Since the crossbred lambs gained so nearly like the Karakuls it was believed that the results obtained from the application of covariance analysis to the Karakul data were representative of the crossbred lambs. Therefore, adjustment for birth weight differences between the crossbred lambs and the other breeds was not made, although differences between mean gains were tested for significance on an unadjusted birth weight basis.

In the comparisons of the Karakul with the Hampshire, Shropshire, Southdown, and Corriedale lambs, if the differences in unadjusted mean gains were not statistically significant, it followed that the differences in the adjusted values also lacked significance. Consequently it appeared that in these instances the differences in birth weights had less influence on subsequent body weights than in cases of significant unadjusted values.

Highly significant differences ($P < .01$) in mean gains at all ages occurred only between the Karakul and Hampshire female lambs, the latter being appreciably larger. Before adjustment for birth weight differences there were highly significant differences in mean gains from birth to 13 and 26 weeks and a significant difference for the 52-weeks period between the Karakul and Southdown female lambs. The Southdown lambs appeared to overcome somewhat the handicap of smaller birth weights as they approached 52 weeks of age, which is shown by a lower probability value for the mean gain difference compared with those for the earlier growth periods. However, after removing the effects of differences in birth weights the gains of the Southdown and Karakul female lambs were not significantly different. The Karakul female lambs appeared to grow more nearly like those of the Shropshire and Corriedale breeds as indicated by the fact that no significant differences in mean gains occurred at any age. As between the Shropshire and Corriedale, probability values would indicate that the female lambs of the latter breed are more nearly like the Karakul in rate of growth.

Less difference in mean gains was found between the Karakul and Hampshire males than between the female lambs of these breeds. After adjustment for birth weight a significant ($P < .05$) difference occurred only during the first 13-weeks period, indicating a similar rate of growth for these two breeds after the lambs reached 3 months of age. The Karakul and Shropshire male lambs attained greater similarity in rate of growth as they became older. This is indicated by the fact that from birth to 13 weeks the difference in adjusted mean gains was highly significant, to 26 weeks significant, and thereafter non-significant. With the exception of the growth period from birth to 26 weeks, there was a significant difference in the adjusted mean gains between the Karakul and the Southdown male lambs. At all ages from birth to 52 weeks the Southdown males were smaller. Compared with the

four mutton breeds the Karakul male lambs were more like those of the Corriedale in rate of growth, as shown by the absence of a significant difference in mean gains at any age.

The mean gains of the Karakul×Corriedale female lambs from birth to 13, 26, and 52 weeks of age were 35.9, 52.5, and 88.3 pounds, respectively. Similarly, the mean gains of the Karakul×Blackfaced Highland lambs for the corresponding growth periods were 41.6, 57.1, and 91.1 pounds. No significant statistical differences in mean gains occurred between the Karakul female lambs and those of either of the two crossbred lines. Neither was there a significant difference in mean gains between the lambs of Karakul ×Corriedale and Karakul×Blackfaced Highland breeding.

Like the Karakuls, the crossbred lambs grew less rapidly and differed significantly from the Hampshires in mean gains from birth to 13, 26, and 52 weeks of age. They were more nearly like the Shropshire and Corriedale lambs in rate of growth as indicated by a lack of significance between their mean differences. Compared with the Southdown, however, the Blackfaced Highland crossbred lambs gained in a manner more nearly like the Karakul, showing significant differences during each of the three growth periods, while the Karakul×Corriedale were similar to the Southdown female lambs in rate of growth.

Summary and Conclusions

Data on growth in Karakul, Karakul×Corriedale, and Karakul×Blackfaced Highland lambs from birth to 52 weeks of age and a comparison of these with data from lambs of the mutton breeds of sheep handled under farm flock conditions are presented. Because of the infrequency of twin births in the Karakul and Karakul crossbred flocks at the United States Department of Agriculture, Beltsville Research Center, Beltsville, Md., only single lambs of the Hampshire, Shropshire, Southdown, and Corriedale breeds at this same station are included in the study. The data are shown graphically as growth curves. Analyses of these data show that:

1. The Karakul and Karakul crossbred lambs were more nearly like the Hampshire lambs than those of the other mutton breeds in size at birth, as shown by similarity of birth weights.

2. Birth weights of Karakul male lambs ranged from 9.3 to 12.8 and of females 6.3 to 12.8 pounds, an average of 11.1 and 10.2 pounds respectively. The Karakul×Corriedale female lambs also averaged 10.2 pounds and those of Blackfaced Highland breeding 10.3 pounds at birth.

3. The growth curves indicated quite definitely that the Karakul and crossbred lambs were smaller than the Hampshire and larger than the Southdown lambs at practically any age from birth to 52 weeks. The growth trend in all the breeds was similar.

4. After adjusting for differences in the average birth weights between breeds, the Karakul lambs in rate of growth showed greatest similarity to the Corriedale lambs, followed in order by the Shropshire, Southdown, and Hampshire breeds. Although the mean birth weights of the Karakul and Hampshire female lambs were practically the same numerically, the rate of growth was much slower for the Karakul, resulting in a highly significant difference in mean gains for the 13-, 26-, and 52-weeks periods. The Karakul × Blackfaced Highland and the Karakul × Corriedale lambs ranked in the same order as the Karakul with respect to their similarity to the Corriedale, Shropshire, Southdown, and Hampshire breeds in rate of growth.

5. The ability of Karakul and Karakul crossbred lambs to grow at a rate comparable with those of some of the best mutton breeds is of economic importance to breeders who find it necessary to raise many of their lambs with inferior fur for meat purposes.

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THE USE OF UREA IN MAKING SILAGE FROM SWEET SORGHUM[1]

A. E. Cullison

IT HAS been observed in making silage from sweet sorghum that the fermentation process apparently continues over an extended period. Sweet sorghum silage stored for several months has been noted to be warm in the sub-surface layers, indicating that some type of active fermentation is still in progress. Such a condition is inconsistent with the generally accepted theory of silage preservation, but has existed when the best known silage-making practices have been followed.

It occurred to the writer that this prolonged fermentation might result from the development of inadequate or undesirable bacterial flora in the silage due to a very low available nitrogen supply in the sweet sorghum plant and, therefore, might be corrected by the addition of a nitrogen supplement to the silage material at silo-filling time. Working along this line, Harris and Mitchell (1941) were able to improve the digestibility of a low protein ration for sheep by supplementing it with urea and explained the improved digestibility as being "consistent with the hypothesis that the addition of urea to such a ration stimulates the proliferation of the paunch flora and enhances carbohydrate fermentation there." In connection with the fermentation of blackstrap molasses for commercial alcohol production Jacobs and Newton (1938) state that "If the molasses is deficient in available nitrogen, ammonium salts are also added to stimulate yeast growth." While these references do not bear directly on the problem at hand, they indicate that nitrogen compounds play an important role in certain processes involving bacterial activity.

There was some question whether the sweet sorghum plant is so low in available nitrogen as to limit its proper fermentation in the silo. Morrison (1936) reports this crop as having an average total crude protein content of 1.5 percent on the wet basis. This figure was recognized as being low in comparison with most other silage crops, and when it was realized that the major portion of this protein was probably within the fibrous cell wall of the sorghum plant where it is largely unavailable for bacterial activity, the probability of a nitrogen deficiency in sweet sorghum silage became apparent.

In view of this possibility, it was decided to add a nitrogen supplement to the sweet sorghum stored in one silo on the Mississippi Experiment Station farm in 1942 and observe the effects of the treatment. It was realized

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that the addition of a nitrogen supplement to the silage material might improve the nature of the fermentation in the silage material, and also increase its protein content and digestibility.

The ability of micro-organisms to assimilate certain simple nitrogenous compounds into proteins has been brought out by the work of Fingerling *et al.* (1937), Bartlett and Cotton (1938), Hart, Bohstedt *et al.* (1939), and Harris and Mitchell (1941). While all the above references deal with the micro-organisms of the ruminant's paunch, it would seem that the findings in this regard should be more or less applicable to the micro-organisms found in silage.

As mentioned previously, the work of Harris and Mitchell (1941) also showed that the digestibility of a low protein ration could be improved by supplementing it with urea. While the ration used in the above work was highly synthetic and much lower in protein than sweet sorghum, the results suggested the possibility of increasing the digestibility of sorghum silage by treating it with a nitrogen supplement.

In the work previously mentioned, urea was the most effective simple nitrogenous compound tested for replacing the protein in the ration of ruminants through the activity of the paunch flora, and was not found to be toxic when fed in limited amounts to cattle or sheep. Accordingly, it was used as the nitrogen supplement in this study. It was sprinkled on the freshly-cut sweet sorghum as it entered the silo at the approximate rate of 10 pounds of urea per ton of silage material, assuming that the thoroughly tramped but unsettled silage material weighed approximately 32 pounds per cubic foot. The above rate for applying the urea was used since it was calculated that this amount would make it possible for a ration of 35 pounds of silage and 5 pounds of Johnson grass hay to meet the protein requirements of a mature beef cow provided that most of the nitrogen in the urea was assimilated into protein by the bacteria of the silage or later by the micro-organisms of the cow's paunch.

Starting on December 16 the urea-treated silage was used in comparison with untreated silage as a feed for wintering beef breeding cows. Two uniform lots of 15 Hereford and Angus cows each were used in this test which extended over a period of 78 days. The rations fed along with the results of the wintering trial are given in table 1.

It may be noted that the cows receiving the urea-treated silage were able to maintain their weight for the duration of the test while cows receiving the untreated silage lost an average of 47 pounds per head. This difference was plainly evident in the appearance of the cows at the end of the test and was definitely significant.

It was also observed that the urea-treated silage was distinctly superior to the untreated silage in palatability. The lot of cows receiving the urea-

treated silage consumed their regular allowance of feed in approximately one-half the time required for the other lot to clean up their allowance of untreated silage. When hay was fed at the same time as silage, cows receiving the urea-treated silage ate this in preference to hay, whereas the other lot showed a distinct preference for hay and, for the most part, ate it all before starting on the untreated silage. In order to make certain that this apparent difference in the palatability of the two silages was not a difference in the eating habits of the two lots of cows, the silages for the two lots were re-

TABLE 1.—UREA-TREATED VS. UNTREATED SILAGE FOR WINTERING BEEF BREEDING COWS

	Rations fed per head daily—78 day period	
	5 lbs. Johnson Grass hay 35 lbs. Urea-treated silage	5 lbs. Johnson Grass hay 35 lbs. Untreated silage
No. of cows in lot	15	15
Average initial wt. per head	930 lbs.	936 lbs.
Average final wt. per head	930 lbs.	889 lbs.
Average loss in wt. per head for period	0 lbs.	47 lbs.

versed the evening following the end of the wintering test. As the result there was a reverse in the usual reaction of the cows in each lot to their rations and previous observations in regard to the relative palatability of the treated and untreated silages were thus verified.

Also a distinct advantage was found in favor of the urea-treated over the untreated silage in carotene preservation. The urea-treated silage after approximately four months' storage contained 34.55 gammas of carotene per gram of dry matter as compared to 22.67 gammas per gram for the untreated silage. Six weeks later analyses of the two silages showed them to contain 35.96 and 15.71 gammas of carotene per gram of dry matter, respectively. This is an advantage for the urea-treated over the untreated silage in carotene content of 52.4 percent for the earlier analyses and 128.9 per cent for the later analyses, with essentially no loss of carotene from the urea-treated silage during the period between the two analyses, whereas there was a considerable loss from the untreated silage. Also the data show a much greater loss of carotene from the untreated than the treated silage during the period previous to the first analysis.

Of possible significance also is the fact that the untreated silage after several months' storage was warm in the sub-surface layers and seemed to be still undergoing fermentation whereas in the urea-treated silage no noticeable fermentation was taking place. Sub-surface temperatures in the untreated

silage read approximately 11 degrees Centigrade higher than did those for the urea-treated silage after four months' storage. Six weeks later this difference still existed.

A limited amount of data was obtained on the acidity of the two silages and an interesting difference was noted in this respect. Whereas the urea-treated silage contained more total titratable acids than did the untreated silage, the latter had a lower pH. This would seem to indicate a difference in the type of fermentation.

The results of this first year's work indicate that there is a distinct benefit resulting from the treatment of sweet sorghum with a small amount of urea at silo-filling time. Apparently the untreated sorghum does not contain adequate available nitrogen for the proper development of a desirable bacterial flora in the silage material.

If such is the case, it is probable that other low protein crops used for silage would respond favorably to this treatment. It is possible that other nitrogen supplements or limited quantities of high protein feeds might be used in place of urea as satisfactorily or more so.

Definite information on all of these points, however, will have to come from further detailed study.

Summary

A prolonged fermentation noted where sweet sorghum alone was used for silage was diagnosed as possibly due to the low available nitrogen content of the plant. In an attempt to overcome this condition, urea was used as a nitrogen supplement to treat the sweet sorghum stored in one silo at the Mississippi Experiment Station in 1942. As a result, the prolonged fermentation was eliminated and the resulting silage was superior in carotene content, palatability, and general feeding value to that ordinarily made from this crop. Further studies are needed on the use of urea and other nitrogenous substances with sweet sorghum and other low protein crops being used for silage.

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THE PHOSPHORUS REQUIREMENT FOR FATTENING LAMBS

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THE importance of supplying adequate amounts of phosphorus to sheep has been recognized generally for many years by workers interested in sheep nutrition. The phosphorus requirement for mature ewes has been extensively studied by Dutoit *et al.* (1930, 1931), Rossouw (1930) and Fraps (1918). Comparatively few studies have been made on the phosphorus requirement for fattening lambs. Mitchell and McClure (1937) have presented an excellent review of literature pertaining to the phosphorus requirement of sheep, and state that very few quantitative experiments concerned with the phosphorus requirement of growing lambs have been found in the literature. Martin and Pierce (1934) reported that Merino lambs receiving 1.60 grams of phosphorus daily met their phosphorus needs. A previous report by Beeson, Bolin and Hickman (1937) indicated that lambs ingesting 2.0 to 2.5 grams of phosphorus daily satisfied their phosphorus requirement.

The work reviewed does not give precise quantitative data as to the minimum phosphorus requirement for fattening lambs. The five experiments described in this paper were designed to determine more quantitatively the phosphorus requirement for fattening lambs and to study the changes occurring in lambs on a low phosphorus diet.

Experimental

In the period extending from 1936 to 1941 five experiments were conducted with western feeder lambs to determine the quantitative phosphorus requirement for growth and fattening. Twenty-seven lots of 25 lambs each were fed varying levels of phosphorus intake over periods ranging from 133 to 143 days. The basal diet consisted of a mixture of dried molasses beet pulp, alfalfa hay, bloodmeal, oyster shell and salt. The exact proportions are given in table 1. Corn silage was fed at the rate of 1 pound per lamb daily to all lambs except those on ration 5 in which dried molasses beet pulp was replaced with wet beet pulp.

The proportion of the alfalfa hay was varied in order to set up basal rations differing in phosphorus content. The calcium content of the rations was maintained at a constant level for the first three experiments (1936–37–38) by including ground oyster shell. No oyster shell was added to the diets in the last two experiments (1939–40) because ample calcium was provided in the

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basal ration. The phosphorus level was varied by the addition of definite amounts of steamed bonemeal as designated in table 2. Cottonseed meal was used as a source of both phosphorus and protein in Lots 22 and 24. The differences in phosphorus percentage occurring with rations of the same number were due to the variation in phosphorus content of the alfalfa from year to year.

TABLE 1.—COMPOSITION OF RATIONS

Component	Ration[1]				
	1	2	3	4	5[2]
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Dried molasses beet pulp	43.7	38.65	65.14	66.5	
Alfalfa hay (chopped)	50.0	50.00	26.00	26.0	77.6
Bloodmeal	5.0		7.00	7.0	20.9
Cottonseed meal		10.00			
Bonemeal					1.5
Oyster shell	.8	.85	1.36		
Salt	.5	.50	.50	.5	

[1] Corn silage was fed at the rate of 1 pound per ewe daily with ration 1 to 4 inclusive.
[2] Wet beet pulp was fed ad libitum with ration 5.

The lambs were fed in open, straw-bedded feed lots and they had free access to water and sunshine. The lambs were weighed every 14 days as a group and the 6 lambs from which blood samples were tken were weighed individually. All rations were weighed and fed twice daily to each lot. Blood samples were taken from the jugular vein of 6 lambs from each lot on the initial and final periods and on 2 to 3 intermediate periods in order to check closely on the calcium and phosphorus level of the blood.

Feed samples were taken at monthly intervals for a complete feed analysis for calcium and phosphorus. All feed and blood analyses were made according to the Methods of Analyses of the Association of Official Agricultural Chemists (1935) with the exception of phosphorus, which was determined colorimetrically by a slight modification of the Fiske and Subbarow (1925) method.

Results and Discussion

A complete summary of the data on 675 lambs involving a series of five experiments (1936–1941) on the phosphorus requirement for fattening is presented in table 2. Because of the large amount of data gathered during the seven years experiments, the material will be presented in a highly condensed form. Each weight listed in the table is an average of 25 lambs. The lots

have been arranged in sequence according to the per cent phosphorus in the ration instead of by experiments, in order to present the results effectively. The composition of the rations is given in table 1.

Rate of Gain. These data indicate that when phosphorus is fed at a sub-optimal level, the rate of growth is closely correlated with phosphorus intake. This is brought out most clearly by noting the gains and phosphorus intake in lots 1 to 11 inclusive. The phosphorus in the ration varied from 0.07 to 0.12 per cent and the average daily gains ranged from 0.18 to 0.23 pound daily. There was some variation in the response of gains to the phosphorus intake due to difference in lambs and feeding conditions from year to year. All the lambs in lots 1 to 11, inclusive, showed abnormally slow gains, high feed requirements and specific symptoms of aphosphorosis, such as depraved appetite, unthrifty appearance and low blood phosphorus.

The rate of growth was increased when lambs received a ration containing 0.14 per cent phosphorus. Although no low blood phosphorus values appeared among the borderline phosphorus group, the rate of growth and feed utilization indicated a partial phosphorus deficiency. A level of 0 per cent phosphorus is apparently on the borderline for lambs. Some of lambs in this group responded very well to the ration fed while others, pecially in years when the late summer and fall ranges had been dry, w unable to satisfy their body needs at this level. The rate of growth of lambs on 0.14 per cent phosphorus varied from 0.22 to 0.26 pound per l daily. The normal gain of a lamb when the concentrates are limited to a 1 pound a day is 0.27 to 0.30 pound daily.

Rations containing 0.15 to 0.23 per cent phosphorus caused a decid crease in the average rate of growth among the lambs in lots 16 to 27 sive. There seems to be no advantage in supplying phosphorus at a above 0.15 per cent of the ration on an air dry basis. Previous work a station (1937) and by Dutoit and co-workers (1931) has shown that f excessive amounts of phosphorus decreases the rate of gain. Howeve , la can be fed rations containing 0.23 per cent phosphorus without decrea the rate of growth (lots 25, 26, 27).

Appetite and Feed Utilization. A low phosphorus diet does not a the appetite of lambs as adversely as aphosphorosis in steers (Beeson 1941). The average air dry food intake of the lambs on phosphorus-defi diets was 2.28 pounds daily, while the lambs on ample phosphorus consumed 2.64 pounds of feed daily. The decrease in food consumptio associated with a depraved appetite manifested by chewing board and eating dirt and wool. Other outward symptoms were a leggy cor tion, listlessness, lack of fat covering and in many cases an extrem kneed condition (Fig. 1).

The utilization of feed was affected more acutely than the appetite. Excepting for the lots fed wet beet pulp (lots 4, 11, 19), the average feed requirement per 100 pounds of gain for the phosphorus-deficient group, the border-line group, and the adequate phosphorus group was respectively 1168, 1062 and 927 pounds. The lambs fed wet beet pulp utilized their feed more efficiently than those on dried pulp rations, probably due to the stimulating effect of the succulent feed. The low phosphorus lambs required 20.6 per cent more air dry feed to grow and fatten than the lambs

Figure 1. A phosphorus deficient lamb. Note the leggy, knock-kneed conformation.

receiving rations containing ample phosphorus. Lambs are similar to steers (Beeson *et al.* 1941) in their reaction to low phosphorus diets in that a phosphorus inadequacy interferes more with the utilization of food than amount eaten.

Blood Phosphorus and Calcium. The average initial and final blood phosphorus values are presented in table 2. These data are based upon average blood samples from 6 lambs from each lot. It was not deemed advisable to bleed all the lambs in each lot because of the unfavorable effect on appetite and gains. Samples of blood were taken at more frequent intervals than given in table 2; usually 5 or 6 samples were collected during the feeding period. Lambs receiving rations containing 0.07 to 0.12 per cent phosphorus or ingesting a daily phosphorus intake of 1.20 to 1.67 grams of phosphorus per 100 pounds of live weight showed a definite lowering of blood phospho-

TABLE 2.—SUMMARY OF DATA ON THE PHOSPHORUS REQUIREMENT FOR FATTENING LAMBS (1936–41)[1]

Lot No.	Year	Days on feed	Ration	Phos. in ration %	Av. Initial wt. lb.	Av. Final wt. lb.	Av. Daily gain lb.	Feed Consumed			Phosphorus Intake		Blood Phosphorus	
								Daily lb.	Per 100 lb. live weight lb.	Per 100 lb. gain lb.	Daily gm.	Per 100 lb. live weight gm.	Initial mg/100 ml.	Final mg/100 ml.
			Phosphorus Deficient Group											
1	1939	140	Ration 4	.07	59	84	.18	2.17	3.04	1207	0.86	1.20	5.11	2.49
2	1939	140	Ration 4+.10 per cent bonemeal	.09	58	84	.19	2.13	3.00	1122	0.92	1.30	5.06	2.61
3	1939	140	Ration 4+.25 per cent bonemeal	.10	58	84	.19	2.28	3.19	1204	1.08	1.51	5.12	3.23
4[2]	1939	140	Ration 5	.10	58	87	.21	2.07	2.85	984	0.92	1.27	5.04	3.37
5	1937	143	Ration 3	.10	64	94	.21	2.41	3.06	1164	1.11	1.41	5.01	3.40
6	1940	133	Ration 4	.11	69	92	.18	2.45	3.05	1386	1.20	1.49	5.60	2.90
7	1939	140	Ration 4+.32 per cent bonemeal	.11	59	87	.20	2.25	3.09	1110	1.18	1.62	4.90	3.71
8	1938	140	Ration 3	.11	64	96	.23	2.42	3.03	1055	1.24	1.55	4.93	3.57
9	1937	143	Ration 1	.12	63	93	.21	2.43	3.10	1161	1.31	1.67	6.10	3.10
10	1936	133	Ration 3	.12	66	95	.22	2.41	3.01	1105	1.32	1.65	5.00	3.28
11[2]	1939	140	Ration 5+.18 per cent bonemeal	.12	57	90	.23	2.10	2.85	894	1.17	1.59	6.04	4.17
			Borderline Phosphorus Deficient Group											
12	1936	133	Ration 1	.14	66	96	.22	2.56	3.15	1155	1.62	2.00	5.36	5.25
13	1938	140	Ration 1	.14	65	100	.25	2.59	3.15	1030	1.59	1.93	5.94	5.20
14	1940	133	Ration 4+.25 per cent bonemeal	.14	69	103	.26	2.74	3.19	1066	1.69	1.96	6.70	4.30
15	1937	143	Ration 1	.14	64	101	.26	2.56	3.11	996	1.63	1.98	5.20	6.00
			Phosphorus Sufficient Group											
16	1938	140	Ration 1 with high phosphorus alfalfa	.15	64	106	.30	2.77	3.24	920	1.90	2.17	5.40	6.27
17	1940	133	Ration 4+.35 per cent bonemeal	.15	69	105	.27	2.72	3.12	1002	1.89	2.17	6.20	7.30
18	1940	133	Ration 4+.50 per cent bonemeal	.17	69	110	.31	2.76	3.08	899	2.16	2.41	6.00	6.60
19[2]	1939	140	Ration 5+.59 per cent bonemeal	.18	58	96	.27	2.18	2.83	804	1.75	2.27	7.06	5.97
20	1938	140	Ration 1+.50 per cent bonemeal	.18	65	108	.31	2.56	2.96	822	2.07	2.40	5 68	6.88
21	1937	143	Ration 1+.70 per cent bonemeal	.20	64	101	.26	2.66	3.23	1014	2.42	2.94	4.70	6.50
22	1938	140	Ration 1+10 per cent cottonseed meal	.20	64	105	.29	2.75	3.26	949	2.56	3.03	5.60	7.10
23	1940	133	Ration 4+.75 per cent bonemeal	.20	69	108	.30	2.70	3.06	912	2.39	2.71	5.60	7.00
24	1937	143	Ration 1+10 per cent cottonseed meal	.22	64	104	.28	2.68	3.20	944	2.68	3.20	5.80	7.40
25	1936	133	Ration 1+.70 per cent bonemeal	.23	65	102	.27	2.64	3.16	977	2.78	3.33	5.07	5.67
26	1940	133	Ration 4+1.00 per cent bonemeal	.23	69	104	.27	2.70	3.12	1004	2.93	3.38	6.10	7.60
27	1938	140	Ration 1+.70 per cent bonemeal	.23	64	107	.31	2.73	3.19	882	2.80	3.27	5.40	6.27

[1] The values are for an average of a group of 25 lambs.
[2] Fed wet beet pulp instead of dried molasses beet pulp.

rus to deficient levels. The average phosphorus level for lambs on the phosphorus-low ration was decreased from a normal of 5.26 mg. per 100 ml. of plasma to a deficient level of 3.26 mg. Although there are some individual variations among lambs in their response of blood phosphorus to their dietary intake of phosphorus, usually the inorganic phosphorus level of the blood may be taken as being indicative of the degree of phosphorus deficiency of sheep. This is in close agreement with the findings of Dutoit et al. (1931). Their studies indicated that the inorganic phosphorus in the blood of sheep remains remarkably constant when the phosphorus content of the diet is unchanged and a change in the phosphorus causes almost immediate change in blood phosphorus. The blood phosphorus values for lambs fed on rations containing 0.14 to 0.23 per cent phosphorus or a daily intake of 1.93 to 3.38 grams of phosphorus per 100 pounds of live weight were all within the normal range.

The time required to deplete a lamb of phosphorus to a level which is reflected in the blood varied from 7 to 90 days, depending on previous feeding conditions and amount of phosphorus in the experimental ration. In 1939 the lambs showed signs of aphosphorosis in 7 days because the range feed during the late summer and fall was dry and mature, and consequently low in phosphorus, and as a result the lambs were partially depleted of their body stores of phosphorus prior to the experiment. The amount of storage of phosphorus in the skeletal and other tissues of the body has a direct relationship to the time required to produce aphosphorosis. In a previous publication Beeson et al. (1941) showed that steers responded similarly to previous feed conditions and the time required to produce aphosphorosis. Calcium content of the blood was determined at the initial and final periods, and the values were all normal.

Phosphorus Requirement for Fattening Lambs. As pointed out in our previous discussion, the lambs in lots 12 to 15, inclusive, receiving 0.14 per cent phosphorus or a daily intake ranging from 1.93 to 2.00 grams of phosphorus per 100 pounds of live weight did not show symptoms of aphosphorosis, but the rate of growth and efficiency of feed utilization showed a need for additional phosphorus. These data indicate that lambs ingesting 2.00 grams of phosphorus daily per 100 pounds of live weight are hardly meeting the minimum phosphorus requirement, especially in years when the previous feed is low in phosphorus. This level of phosphorus intake does not assure normal growth and fattening and therefore cannot be taken as adequate. At least for practical feeding it is too near the borderline, where unavoidable circumstances may result in a deficiency of phosphorus. Lambs apparently have a higher phosphorus requirement per unit of body weight than steers because studies by Beeson et al. (1941) with steers have shown that 2.0 grams per hundred weight is sufficient.

An adequate phosphorus intake as determined by rate of gain, feed utilization, appetite and inorganic blood phosphorus level may be met by phosphorus intakes varying from 2.17 to 3.38 grams daily per 100 pounds of live weight or from 1.75 to 2.93 grams of phosphorus per lamb daily. This requires the feeding of rations containing 0.15 per cent or more of phosphorus. Excellent gains and food utilization values were obtained in lots 18 and 20, with an intake of approximately 2.40 grams per hundred weight. Although a somewhat lower level may be adequate, due to the different conditions under which lambs are fattened, it is suggested that optimum phosphorus requirement for fattening a lamb be set at 2.40 grams per 100 pounds of live weight or the ration should contain 0.17 per cent or more phosphorus. These requirements are only slightly higher than data reported by Mitchell and McClure (1937) in which they estimated that growing Shropshire lambs ranging in weight from 50 to 90 pounds had an average feed phosphorus requirement of 2.16 grams daily per 100 pounds of body weight.

It has been shown (Table 2) that diets furnishing from 1.20 to 1.67 grams of phosphorus daily per 100 pounds of live weight are not capable of supporting normal growth and blood phosphorus levels in lambs. Rations made up of feeds containing 0.12 per cent or less phosphorus are deficient and rations with 0.14 per cent phosphorus are on the borderline of being too low for normal growth and well being.

Cottonseed Meal as a Phosphorus Supplement. Cottonseed meal was added to the basal ration as a phosphorus and protein supplement to replace blood meal and bonemeal. Lots 22 and 24 were fed cottonseed meal at the rate of 10 per cent of the basal mixture, which provided respectively 0.20 and 0.22 per cent phosphorus in the ration. The lambs on cottonseed meal as a source of phosphorus grew and fattened as rapidly and efficiently as lambs receiving bonemeal as a source of phosphorus. This leads to the conclusion that the phosphorus in cottonseed meal is an effective source of phosphorus and has the additional value of supplying protein, if needed. Thus cottonseed meal lends itself to serve not only as an excellent protein supplement but also as a suitable phosphorus supplement.

Summary

Experiments to determine the phosphorus requirement for fattening lambs have been carried out employing 675 western lambs in a series of five experiments. Lambs fed on rations containing 0.07 to 0.12 per cent phosphorus or an intake of 1.20 to 1.67 grams of phosphorus per 100 pounds live weight showed abnormally slow gains, high feed requirements, and specific symptoms of aphosphorosis such as depraved appetite, unthrifty appearance and low blood phosphorus. A level of 0.14 per cent phosphorus in the diet indicated a borderline phosphorus deficiency, which proved to be inadequate

for normal growth and feed utilization. Lambs receiving rations with a phosphorus content ranging from 0.15 to 0.23 per cent were adequately supplied with phosphorus as indicated by good rate of gain, efficient feed utilization and normal blood phosphorus levels. On the basis of phosphorus intake per unit live weight, lambs receiving from 2.17 to 3.38 grams daily per 100 pounds of live weight will meet their phosphorus requirement.

Although a somewhat lower phosphorus level may be adequate, due to the different conditions under which lambs are fattened, it is suggested that the optimum feed phosphorus requirement for fattening lambs be set at 2.40 grams per 100 pounds of live weight or the ration should contain on a dry basis 0.17 per cent or more phosphorus.

These results indicate that a phosphorus deficiency in lambs exerts a more depressing effect on the utilization of the feed than on the appetite.

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IODINE-FLUORINE RELATIONSHIPS IN SHEEP NUTRITION[1]

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THE effects of dietary fluorine upon various body functions have been studied by numerous investigators during recent years. As summarized by McClure (1933) in a review paper, there was fairly general agreement that excessive fluorine resulted in a decreased rate of growth, the production of mottled teeth and weakened bones. Numerous reports of the effects of dietary fluorine upon the size and histology of the thyroid gland have been published but the results have been highly controversial.

Maume (1854), Houssay (1920), Goldemberg (1926) and Christiani (1930) reported that the ingestion of sodium fluoride resulted in increased size and abnormal histological structure of the thyroid gland. Tolle and Maynard (1931) and Kick and co-workers (1935) found no relationship between fluorine intake and thyroid weight in rats and Hauck et al. (1933) reported similar results in chicks. Pierce (1938) fed fluorine containing minerals to sheep for three years without gross or microscopic changes in the thyroid gland. In none of these experiments was any attempt made to regulate iodine intake. Hatfield, Shrewsbury and Doyle (1942) reported that in growing lambs thyroid weight decreased markedly as dietary fluorine was increased. No attempt to regulate dietary iodine was made.

Thyroid size and histology are greatly affected by iodine intake, growth and general body metabolism are intimately related to thyroid function and fluorine has been reported to influence these processes in various ways. These experiments demonstrate the effects of feeding various levels of fluorine in conjunction with rations containing adequate and inadequate amounts of iodine.

Materials and Methods

Three experiments were conducted in which lambs of uniform history and weight were divided into four lots of five lambs each. The lambs were fed individually 2–3 pounds of legume hay and 1 pound of ground yellow corn daily. In addition rock phosphate (fluorine = 3.85 per cent) was fed in amounts that would furnish 1.5, 3.0 and 6.0 milligrams of fluorine per kilogram of body weight daily. Steamed bone meal was added to adjust the calcium and phosphorus content of all feeds to an equal level.

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In the first experiment western feeding lambs were used while in the second and third, lambs from experimental ewes receiving the same amounts of fluorine that were fed to the lambs were employed. In the first experiment the lambs were allowed free access to block salt and consumed 1.0, 1.0, 1.2 and 1.6 pounds per lamb in lots 1, 2, 3 and 4 respectively. This resulted in a variable intake of iodine since the salt contained some iodine. In the second experiment each animal received the same amount of salt which contained no iodine and in the third trial iodized salt containing approximately 0.01 percent potassium iodide was fed. At the end of the feeding trials the lambs were slaughtered and the thyroid glands removed for analysis. The pituitary glands also were secured from the lambs in the second and third experiments.

At slaughter the thyroid glands were immediately removed and weighed and small portions fixed in Bouin's fluid for subsequent histological study. The remainder of the gland was analyzed for iodine by the method of McCullagh (1934).

The pituitary glands were recovered at autopsy and immediately frozen. The anterior lobes were subsequently dissected out and combined in experimental groups. The thyrotropic hormone content of the anterior hypophysis (pituitary) was determined. The technique employed included grinding the glands in pure silica sand and suspending the finely ground material in distilled water in the proportions of 1 ml. of water for each 50 mgm. of tissue. Male white leghorn chicks were injected with 0.1 ml. daily for four consecutive days beginning on the second day after hatching. The chicks were sacrificed on the day following the last injection and their thyroid glands dissected and weighed. This method, a slight modification of that described by Bergman & Turner (1939), gives an estimate of the relative thyrotropic hormone content of the various groups of pituitaries.

Results

In all three experiments the lambs which received the greatest amount of fluorine (6 mgm. per kg. of body weight daily) grew less rapidly than the controls on a fluorine-free ration (Table 1). In the second trial there was a gradual depression in growth rate as fluorine intake was increased but in the first and third experiments intermediate levels of fluorine did not affect growth. Growth was approximately the same in experiments 2 and 3 indicating that the feeding of fluorine to breeding ewes for two years had no cumulative effects on the growth of their lambs.

The rations fed in experiments 1 and 2, with the exception of fluorine content, were similar to those which have been regarded as adequate for sheep on Indiana farms. It was not intended that iodine be a limiting factor in these experiments, but as was subsequently shown in experiment 3,

TABLE 1. THE EFFECT OF FLUORINE ON THE GROWTH AND THYROID GLANDS OF FATTENING LAMBS AS INFLUENCED BY THE IODINE IN THE RATION[1]

Lot[2] no.	No. of lambs	Fluorine intake per kg. body weight	Average initial weight of lambs	Average total gain of lambs	Average weight of fresh thyroid	Average dry weight of thyroid	Average iodine in thyroid, dry
		mgm.	pounds	pounds	grams	grams	per cent
1st Experiment							
1	5	0.0	61.0	39.8	12.01	2.60	0.009
2	5	1.5	60.0	43.0	6.98	1.68	0.037
3	5	3.0	60.0	47.0	4.08	1.12	0.071
4	5	6.0	61.0	30.8	2.00	.58	0.160
2nd Experiment							
1	5	0.0	65.7	43.2	12.78	4.08	0.011
2	5	1.5	72.4	36.6	4.57	1.35	0.025
3	5	3.0	73.4	30.5	2.49	0.90	0.026
4	5	6.0	68.1	26.8	1.92	0.40	0.029
3rd Experiment							
1	4	0.0	61.1	38.4	3.78	0.86	0.233
2	4	1.5	60.8	34.2	5.15	1.33	0.257
3	4	3.0	62.8	35.5	3.75	1.09	0.286
4	4	6.0	66.3	23.7	3.13	0.98	0.300

[1] Plain salt fed in experiments 1 and 2. Iodized salt containing 0.008 per cent potassium iodide fed in experiment 3. Salt consumption equalized in experiments 2 and 3, fed ad libitum in experiment 1.

[2] Ration: Corn and legume hay. Duration of 1st experiment, 170 days; second experiment 235 days; third experiment 180 days.

iodine intake had a marked effect on the results that were obtained. Thyroid weight was markedly decreased by the addition of fluorine to the iodine-low rations fed in experiments 1 and 2 (Table 1) and in both studies the smallest glands were obtained from the lambs receiving the greatest amount of fluorine. In the third trial all lambs were fed equal amounts of iodized salt and no significant differences in thyroid weight were observed.

Marine (1909) reported that the normal sheep thyroid contains 0.247 per cent iodine. Iodine analysis of the glands (Table 1) indicate that in experiments 1 and 2 iodine content was far below this level and was well within the normal range when iodine was added to the rations. In each experiment the addition of fluorine increased the per cent of iodine in the thyroid gland, even when iodine intake was controlled as in experiment 3. However, the

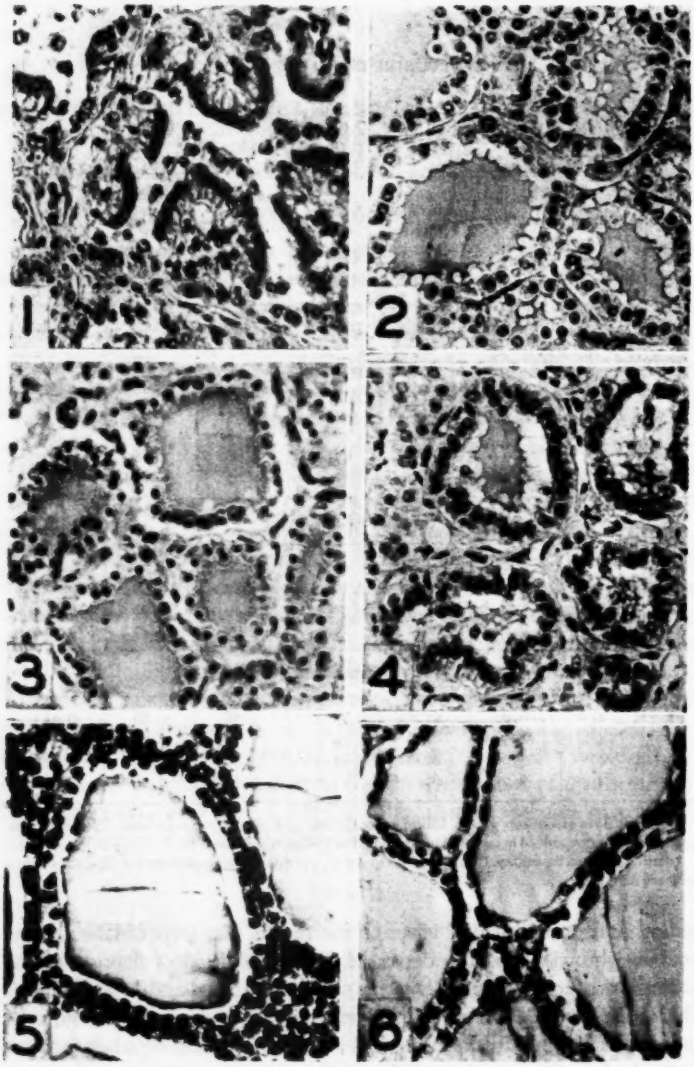

Figure 1. Experiment 2, no fluorine. Observe the hypertrophy and hyperplasia of the epithelium and the absence of colloid.

Figure 2. Experiment 2, low fluorine. Note the reduction in epithelial cell height and the presence of colloid.

Figure 3. Experiment 2, intermediate fluorine. Similar to figure 2.

Figure 4. Experiment 2, high fluorine. Observe some reduction in stored colloid.

Figure 5. Experiment 3, no fluorine. The addition of iodine has decreased height of epithelium and increased storage of colloid. Contrast with figure 1.

Figure 6. Experiment 3, high fluorine. Essentially similar to figure 5.

Magnification of all photomicrographs, 250×.

total iodine content of the gland was increased with fluorine increase in experiment 1, decreased in experiment 2 and a variable effect was obtained in experiment 3. In experiment 3 the total iodine in the gland from lots where fluorine was fed was higher than where no fluorine was fed. The significance of this finding is not clear and it will be discussed in further detail in subsequent paragraphs.

In experiments 2 and 3 portions of the thyroid gland of each lamb were prepared for microscopic examination. The histological study of the glands in experiment 2 revealed that all were distinctly atypical. The thyroids of the control lambs showed evidences of hypertrophy and hyperplasia of the follicular epithelium. The epithelium was of the high columnar type, the nuclei were large and crowded and little stainable colloid was present (Figure 1). The microscopic structures and iodine analyses were similar to those which Marine (1909–1928) has described as characteristic of iodine deficiency in sheep. When increasing amounts of fluorine were added to the control ration there was a progressive decrease in thyroid size and a marked increase in iodine content of the glands of the fluorine-fed lambs. These changes were accompanied by marked changes in thyroid histology. Evidences of hypertrophy were present in all of the fluorine groups but the hyperplasia observed in the controls was absent (Figures 2, 3 and 4). The amount of stainable colloid in lots 2 and 3 was much greater than in the controls and in lot 4 (highest fluorine level) although the colloid decreased in amount, it was more abundant than in the controls. The height of the thyroid epithelium in the controls was significantly greater than in the fluorine lots. When supplementary dietary iodine was fed in experiment 3, thyroid size was reduced and iodine content was raised to the normal level. The histological study of the glands of all animals revealed a low cuboidal epithelium and abundant stainable colloid in all glands. The hypertrophy and hyperplasia which were observed in experiment 2 were absent and the thyroids were normal from all histological standards (Figures 5 and 6). Iodine analyses of the thyroids from the various lots revealed a progressive increase in stored iodine as the fluorine intake was raised. Measurements of the height of the thyroid epithelium showed that as fluorine intake increased there was a progressive and highly significant decrease in cell height (Table 2). It would appear, therefore, that the addition of fluorine to an iodine adequate or inadequate ration tended to result in increased iodine storage, increased amounts of colloid and decreased height of the thyroid epithelium.

The thyrotropic hormone content of the anterior pituitary glands of the various lots was determined in experiments 2 and 3. The pituitaries from the lambs in each lot were combined into one sample and 24 chicks were injected in the assay of each lot. In addition to the chicks which were injected with the pituitaries of the control lot (fluorine-free) a separate group of uninjected

TA E 2. MEASUREMENTS OF THE HEIGHT OF THE EPITHELIAL TISSUE OF E THYROID GLANDS AND THYROTROPIC HORMONE CONTENT OF THE PITUITARY GLANDS OF LAMBS RECEIVING DIFFERENT AMOUNTS OF FLUORINE

Lot no.	No. of amb th roids	Fluorine intake per kg. body weight	No. of measurements on each gland	Average height[1] of thyroid epithelium	Average weight of thyroids of chicks injected with extracts of sheep pituitary[2,3]	Increase over control of thyroids of chicks injected with extracts of sheep pituitary
		mgm.		microns	mgms.	per cent
			Experiment 2			
1	5	0.0	20	17.64	7.23	59
1	5	1.5	20	15.72	6.15	35
3	5	3.0	20	14.55	5.83	28
4	5	6.0	20	15.69	5.15	13
Control					4.56	
			Experiment 3			
1	4	0.0	20	6.88	6.21	1.5
2	4	1.5	20	6.08	5.94	0.9
3	4	3.0	20	5.51	6.21	1.5
4	4	6.0	20	5.39	6.32	1.7
Control					5.40	

[1] Least difference required for significance (t.01), experiment 2 = 1.80 microns; experiment 3 = 2.20 microns.
[2] Chick assay of sheep pituitary for thyrotropic hormone. See text for method.
[3] Least difference required for significance (t.01), experiment 2 = 0.92 milligrams; experiment 3 = 1.1 milligrams.

chicks was included for comparative purposes. The results were subjected to an analysis of variance (Snedecor—1940) and are presented in table 2. In the second experiment, when no supplementary iodine was fed, the pituitaries of the control lambs contained significantly more thyrotropic hormone than did those of any other lot. The assay of the glands in lot 4 showed them to contain significantly less hormone than those of any other lot and lots 2 and 3 did not differ significantly from each other. In the third experiment when iodine intake was adequate and controlled between lots no significant differences in pituitary thyrotropic hormone were observed. It is interesting, also that the addition of iodine to the various rations de-reased the relative thyrotropic hormone content of the pituitaries of the bs in experiment 3 as compared to experiment 2.

he results of these experiments suggest that earlier disagreement in the

literature with respect to thyroid size and fluorine intake might have been due to a variable iodine content of the basal ration employed. Previous workers did not specify whether their rations contained adequate iodine.

Summary

1. The growth of lambs was adversely affected by the fluorine from rock phosphate in the ration in amounts furnishing 6.0 milligrams of fluorine per kilogram of body weight and in lesser degree when smaller amounts were fed.

2. The addition of iodine to the ration did not counteract the deleterious influence of fluorine on the growth of lambs.

3. Lambs fed rations from this area of Indiana were deficient in iodine as evidenced by chemical and histological study of the thyroid glands.

4. Lambs fed rations supplemented with iodized salt had thyroid glands that were normal with respect to iodine content and microscopic structure of the thyroid gland.

5. The presence of fluorine in the ration increased the per cent of iodine in the thyroid glands of lambs both under conditions of adequate and inadequate iodine intake. However, the total iodine content of the gland increased with fluorine intake in some of the experiments and decreased in others.

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FERTILITY OF RANGE BEEF CATTLE[1]

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FERTILITY is an important factor in range cattle production, since the size of the calf crop has a direct bearing on ranch income. Knowledge of the causes of low fertility and sterility and recognition of the importance of analyzing the losses from these two sources, as distinguished from other losses, are of value to range cattle producers.

Some indication of the level of fertility of bulls may be obtained in advance of the breeding season by examination of semen, but a knowledge of fertility in cows in a range herd is not available until the calving season is over. At the U. S. Range Livestock Experiment Station all cows have been culled that failed to produce living calves in two successive years. While not entirely satisfactory, this practice forms a good basis for operating under range conditions, and has been effective in maintaining fertility in the herd.

Review of Literature

Several studies have been made which indicate that the average level of fertility in range beef herds is rather low. Phillips (1939) summarized data from 16 sources in the entire western range area which showed a range of from 40 to 70 per cent calf crop with an average of 63 per cent. The calf crop in Montana and adjacent regions is apparently somewhat higher than in some other regions of the west since Johnson (1930) found that the average calf crop of 60 typical ranches in Montana, North and South Dakota, and Wyoming was 74 per cent. Calf loss between birth and December 31 of the same year amounted to 6 per cent. Saunderson and Richards (1931) studied 95 typical range cattle outfits in Montana and found that the calf crop averaged about 70 per cent while those ranches which maintained cow herds and marketed the younger animals obtained close to an 80 per cent calf crop.

Some work has been reported on the causes of low calf crops. Wilson, et al. (1928) found that there was a tendency for smaller ranches to have the highest calf crops. The percentage varied from 51 for ranches having over 450 cows to 70 per cent for those with 50 cows or less. Johnson (1930) states that the major factors affecting the size of the calf crop in North Dakota are the condition of the breeding herd, particularly that of the bulls, during the breeding season, the amount of available grass and the topography, and the

[1] Based on records of experimental herds cooperatively maintained by the United States Department of Agriculture and the Montana Agricultural Experiment Station. The authors acknowledge the helpful advice and assistance of Ralph W. Phillips and Bradford Knapp, Jr., in the planning of this study and in analyzing the data.

[2] U. S. Range Livestock Experiment Station, Miles City, Montana.

extent of the breeding ground. He pointed out that when animals are gaining in flesh during the breeding season due to good pastures, a high percentage of calves is almost invariably produced. He also pointed out that the practice of breeding yearling heifers results in a high percentage of death losses and a low calf crop.

Phillips (1939) pointed out that failures in reproduction occur frequently in all classes of live stock in the form of either permanent or temporary sterility or of lowered fertility, and that the cases of lowered fertility and temporary sterility are probably more costly than those of complete sterility since the latter may be soon noted and eliminated. On the other hand a male or female of reduced fertility or with recurring periods of temporary sterility may be retained for years thus reducing the breeding efficiency of the herd or flock.

Under range conditions the level of nutrition and the existence of specific deficiencies in the diet may play an important part in determining the level of fertility. Freedman and Turner (1939) have reviewed the literature dealing with losses in reproduction and concluded, with a few notable exceptions, that the dietary requirements for reproduction, qualitatively and quantitatively, do not affect the requirements for maintaining mature animals in good health. Under range conditions it seems probable that deficiencies such as protein, vitamin A, and phosphorus would have a marked effect on the level of reproduction.

Material and Methods

A herd of purebred and grade beef cattle at the U. S. Range Livestock Experiment Station, Miles City, furnished data for a study of: (1) The herd breeding and calf production by years; (2) the relation of age of cows at breeding time to fertility; (3) the fertility record of bulls by age groups and (4) the fertility of bulls where single and multiple herd sires were used. This included a study of weight losses in bulls during the breeding season. With the exception of the initial year, the cows were bred to drop calves as three-year-olds, through a 7 to 8 weeks period beginning about April 8. Breeding and calving operations, with few exceptions, were carried out under range conditions. The bulls were weighed at the beginning and close of the breeding seasons. The cows were used in various wintering trials varying from native range all winter without supplement to a liberal use of alfalfa hay in the feed lot. The calves were weaned in late October each year to allow the cows an adequate period to recover summer weight losses before the arrival of cold weather. The cows were retained in the herd as long as their physical condition and production records were satisfactory. Culling operations were carried out in the spring at the time breeding herds were sorted and in the

fall prior to the winter range period. Culling factors aside from physical condition and extreme age included (a) positive reaction to the blood test for brucellosis, (b) failure to conceive during two successive years, (c) undesirable type and conformation, (d) unsatisfactory calf production, and (e) lumpy jaw and cancer eye.

Data and Discussion

Herd Breeding Data. The total calf production or fertility record in the breeding herd for the 18-year period is shown in table 1. The cows that calved in 1925 were bred before the herd was purchased and included two-year-old heifers which dropped calves from February through November. From 1925 on, the breeding and subsequent calving seasons were limited to a 7- to 8-week period, the only exception being "catch" calves from two-year-old heifers which have been included in table 1. The peak in production was in 1939. Three periods of low production occurred during the 18-year period—1926, 1935 and 1937. The low production in 1926 was the result of changing to a controlled breeding period, and many cows were carrying calves during the breeding season.

TABLE 1. SUMMARY OF HERD BREEDING DATA BY YEARS

Cows in herd each spring		Production results				Production calculations				
		Cows		Calves		Cows		Calves		
		Dry	With calf	Born alive	Weaned	Dry	With calf	Normal births	Weaned	Loss to weaning[1]
Year	Number	Number	Number	Number	Number	Per cent	Per cent	Per cent	Per cent	Per cent
1925	106	15	91	89	86	14.2	85.8	84.0	81.1	5.5
1926	104	29	75	75	72	26.9	72.1	72.1	69.2	4.0
1927	126	12	114	97	90	9.5	90.5	77.0	71.4	21.1
1928	161	24	137	130	126	14.9	85.1	80.7	78.3	6.8
1929	168	37	131	126	125	22.0	78.0	75.0	74.4	4.6
1930	186	16	170	161	159	8.6	91.4	86.6	85.5	6.5
1931	234	27	207	204	201	11.5	88.5	87.2	85.9	2.9
1932	291	47	244	238	232	16.2	83.8	81.8	79.7	4.9
1933	331	39	292	287	279	11.8	88.2	86.7	84.3	4.1
1934	353	52	301	295	288	14.7	85.3	83.6	81.6	4.3
1935	366	84	282	263	259	23.0	77.0	71.9	70.8	8.2
1936	314	46	268	257	251	14.6	85.4	81.8	79.9	6.3
1937	233	74	159	154	150	31.8	68.2	66.1	64.4	5.7
1938	290	28	262	256	250	9.7	90.3	88.3	86.2	4.6
1939	305	20	285	282	276	6.6	93.4	92.5	90.5	3.2
1940	351	30	321	313	305	8.5	91.5	89.2	86.9	5.0
1941	388	47	341	338	328	12.1	87.9	87.1	84.5	3.8
1942	446	57	389	383	372	12.8	87.2	85.9	83.4	4.4
Totals and averages	4753	684	4069	3948	3849	14.4	85.6	83.1	81.0	5.4

[1]Dead calves divided by cows with calf.

The low fertility evidenced in 1935 and 1937 followed the severe drought years of 1934 and 1936, when unsatisfactory grazing conditions prevailed throughout the breeding season. The heavy calf loss in 1927 was due to inclement weather during the calving period. The entire breeding herd was fed hay from late October, 1936, through April, 1937, on a relatively small feeding area, as compared to normal pasture space. The 1937 calving operations were also carried out on this feeding ground. An outbreak of brucellosis which occurred during the winter of 1936–37, is typical of a management problem that may occur when breeding cows carrying a light abortion infection are concentrated or confined to a relatively small feeding area.

TABLE 2. FERTILITY OF RANGE BEEF COWS BY AGE GROUPS, INCLUDING 412 COWS BORN BETWEEN 1925 AND 1931, INCLUSIVE

Age group at calving time		Production results				Production calculations			
		Cows		Calves		Cows		Calves	
		Dry	With calf	Born alive	Born[1] dead	Dry	With calf	Born alive	Born[2] dead
Years	*Number*	*Number*	*Number*	*Number*	*Number*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
3	412	62	350	334	16	15.05	84.95	81.06	4.57
4	397	77	320	308	12	19.40	80.60	77.58	3.75
5	341	48	293	284	9	14.08	85.92	83.28	3.07
6	288	45	243	235	8	15.63	84.37	81.59	3.29
7	219	41	178	173	5	18.72	81.28	78.99	2.80
8	176	26	150	147	3	14.77	85.23	83.52	2.00
9	128	17	111	109	2	13.28	86.72	85.15	1.80
10	76	12	64	59	5	15.79	84.21	77.63	7.81
11	37	7	30	30	0	18.92	81.08	81.08	0.00
Totals and averages	2,074	335	1,739	1,679	60	16.16	83.84	81.00	3.45

[1] Abortions, stillbirths or losses due to inclement weather.
[2] Basis dead calves divided by cows with calf.

An analysis of the yearly variations by the X^2 test clearly indicates a highly significant variation by years on the calf crop percentage ($p < .01$).

This variability was present notwithstanding the fact that the cows were fed a supplement of hay during extremely dry range conditions. The calf crops probably would have been lower in the drought years if the cows had not been fed. The income of the rancher is determined to a considerable extent by the weather conditions during the breeding and calving seasons.

Relation of Age of Cows at Breeding to Fertility. Calving and fertility

records for 412 cows born during a 7-year period from 1925 through 1931, that were bred to calve at three years of age, and dropped calves from 1928 to 1942, inclusive, were studied to observe the relation of age of cow at breeding time to fertility. The data as shown in table 2 have been tabulated and arranged according to an age unit classification, for the seven replacement groups, thus eliminating variation due to years. The cows were bred in herds varying in size from 25 to 155 head. An analysis shows that age of cow was not significant ($P = 0.60$) and a study of the figures does not show any definite trend. The lowest calf crop was observed in the 4-year-old cows

TABLE 3. CAUSES OF DISPOSAL OF RANGE BEEF COWS BY AGE GROUPS, INCLUDING 412 COWS BORN BETWEEN 1925 AND 1931 INCLUSIVE

Age group at calving time	Causes of disposal[2]							
	Dry two years		Abortion or reactors		Dead[2] during year		Other sales[1]	
Year	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
3			1	.24	9	2.18	5	1.21
4	31	7.52	16	3.88	3	.72	6	1.45
5	6	1.45	8	1.94	17	4.12	22	5.33
6	8	1.94	17	4.12	6	1.45	38	9.22
7	5	1.21	10	2.42	6	1.45	22	5.33
8	4	.97	2	.48	3	.72	39	9.46
9	2	.48	6	1.45	1	.78	43	10.43
10	1	.24	3	.72	1	.24	34	8.25
11	0	.00	0	.00	1	.24	36	8.73
Totals an averages[2]	57	13.83	63	15.29	47	11.40	245	59.46

[1] Includes sales for undesirable type, unsatisfactory production, old age and cancer eye, lumpy jaw, etc.
[2] All calculations basis 412 head.

and the highest in the 9-year-old group. Undoubtedly the effect of selection for cows of high fertility has definitely aided in maintaining a high level of fertility in the older groups.

It is shown in table 3 that about 80 per cent of the cows proved to be shy breeders were disposed of by the time they were 6-year-olds. More than half of the shy-breeding cows were disposed of as 4-year-olds. Reactors to brucellosis and deaths on the range were more numerous also in the younger age groups. The indications are, then, that the majority of the shy breeders, poor producers, weak cows, and abortion reactors are eliminated by the time they are 6 years of age. Knapp et al. (1942) have shown that breeding cows reach their maximum production of weaned calves by 6 years of age. These studies show that the majority of the infertile, poor-producing cows are

disposed of prior to maximum production and it would seem that cows 6 to 9 years of age are the mainstays of the herd. The elimination of infertile, and poor producing cows makes more efficient use of western range lands.

Fertility of Herd Sires. A study of differences in the fertility record of Hereford bulls bred to station cows is shown in table 4. These results are based on 19 sires that were 2 years old or over at the time of service. These

TABLE 4. SUMMARY OF FERTILITY OF DIFFERENT SIRES

Designation of bull	Years in service	Cows spring count	Fertility record				Fertility record				
			Cows		Calves		Cows		Calves		
			Dry	With calf	Born alive	Weaned	Dry	With calf	Born alive	Weaned	Loss to[3] weaning
		Number	*Number*	*Number*	*Number*	*Number*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
D	2	64	17	47	47	43	26.6	73.4	73.4	67.2	8.5
E[1]	5	180	11	169	171	165	6.1	93.9	95.0	91.7	2.4
F	4	109	10	99	97	94	9.2	90.8	89.0	86.2	5.1
G	2	61	8	53	52	52	13.1	86.9	85.2	85.2	1.8
H	5	170	29	141	137	136	17.1	82.9	80.6	80.0	3.5
K	2	55	30	25	25	25	54.5	45.5	45.5	45.5	0.0
P	3	68	10	58	57	55	14.7	85.3	83.8	80.9	5.2
Q	4	80	11	69	67	66	13.7	86.3	83.8	82.5	4.3
R	8	209	19	190	183	180	9.1	90.9	87.6	86.1	5.3
S	7	191	27	164	157	151	14.1	85.9	82.2	79.1	7.9
T	3	86	8	78	75	73	9.3	90.7	87.2	84.9	6.4
U[2]	2	77	13	64	65	65	16.9	83.1	84.4	84.4	0.0
680	2	50	3	47	45	43	6.0	94.0	90.0	86.0	8.5
713	2	49	4	45	43	43	8.2	91.8	87.8	87.8	4.4
1894	4	116	11	105	101	99	9.5	90.5	87.1	85.3	5.7
1986	2	55	8	47	47	47	14.5	85.5	85.5	85.5	0.0
2313	2	68	7	61	58	56	10.3	89.7	85.3	82.4	8.2
2557	2	53	4	49	49	45	7.5	92.5	92.5	84.9	8.2
2631	2	62	5	57	54	50	8.1	91.9	87.1	80.6	12.3
Total (19)	64	1803	235	1568	1530	1488	—	—	—	—	—
Mean		28.2	13.0	87.0	84.9	82.5	13.0	87.0	84.9	82.5	5.1

[1] Two pairs twins raised.
[2] One pair twins raised.
[3] Based on fertile cows and weaned calves.

sires were used for a minimum of 2 years and were alone in breeding herds. Bulls designated by letter were purchased while bulls designated by number were calved in the station herd. The cows were managed as previously explained and the bulls were maintained in good breeding condition. Supplemental feeding was not followed during the 7 to 8 weeks breeding season. Cows bred to bull "E" and bull No. 680, a son of "E," had the highest fertility records, while cows bred to bull "K" had the lowest fertility record. This bull had been highly fitted and failed to respond satisfactorily to range breeding practices. Bull "R" settled approximately 5.0 per cent more cows

than bull "S," his half-brother, both bulls being in service in the breeding herds for seven years or more and handled under identical conditions. A statistical analysis indicates a highly significant variation ($P < .01$) in calf crop percentages among the bulls studied. Recent studies on semen quality of beef bulls (Phillips et al. 1943) indicate that a high proportion of the variability of semen quality can be attributed to variations between bulls. The variations in fertility recorded in table 4 show the value of quickly identifying the poor-breeding bull and eliminating him from the herd. It may be of value to test bulls for semen quality before the breeding period in order to eliminate the partially sterile bulls.

TABLE 5. FERTILITY OF BREEDING HEREFORD BULLS BY AGE GROUPS

Age at time of service in years	Number of head	Cows—spring count		Cow fertility record					Bull weights	
				Cows		Calves				
		All	Per bull	Dry	With calf	Born alive	Weaned	Loss to[5] weaning	Beginning[4] breeding season	Average gain or loss
		Number	Number	Per cent	Per cent	Per cent	Per cent	Per cent	Pounds	Pounds
2	9	211	23.4	10.4	89.6	85.8	83.4	6.9	1257	+ 9
3	12	330	27.5	14.5	85.5	83.3	79.5	8.2	1538	− 98
4	8	212	26.5	17.5	82.5	78.8	76.4	7.4	1627	−103
5	10	280	28.0	12.1	87.9	86.4	85.0	3.3	1776[1]	−144
6	9	303	33.7	11.6	88.4	87.1	86.5	1.5	1807[2]	−123
7	7	207	29.6	10.1	89.9	88.4	86.0	4.3	1850	−180
8	4	113	28.3	15.9	84.1	81.4	80.5	4.2	1790[3]	−143
9	3	93	31.0	17.2	82.8	82.8	78.5	5.2	1871	−171
10	2	54	27.0	7.4	92.6	90.7	90.7	2.0	1736	−211
Totals and averages	64	1803	28.2	13.0	87.0	84.9	82.5	5.1	1650	−112

[1] 9 head. [2] 8 head. [3] 3 head. [4] 61 head

[5] Based on fertile cows and weaned calves—includes abortions, stillbirths and accidental deaths.

Herd Sire Fertility by Age Groups. A rearrangement of breeding data in table 4, with the same number of cows and bulls involved but showing herd-sire-fertility by age-groups is presented in table 5. This table also gives average weight losses by bulls during the breeding seasons. An analysis of the effect of age on fertility indicates that there was not a significant difference between ages ($P = .20$) nor was there any apparent trend. Age of bull was not a contributing factor in determining the percentage of calf crop but it did have a material effect on the loss in weight of the bulls during the breeding season. There was a distinct trend for the older bulls to lose more weight than the younger bulls. This makes necessary more care and supplemental feeding of the aged bulls if these animals are to remain in the breeding herds. There is an advantage in using older bulls on the range for these older

animals should either have been disposed of for low fertility or have proven themselves to be sure breeders and the careful rancher has a fair idea of the quality of calves sired by them. A 7- to 10-year-old sire of proven ability may be much more valuable than the younger unproven sire.

Single Versus Multiple Bulls in Breeding Herds. In many instances a low calving percentage may be due to management and not to poor grazing conditions, or low fertility in either the breeding cows or the herd sires. Bulls have a tendency to congregate and cows to scatter in isolated groups, particularly in rough well-watered breeding pastures. This inclination will result in a poor calf crop unless the operator is exceedingly vigilant throughout the period. A comparison of single and multiple bull breeding herds is

TABLE 6. FERTILITY OBTAINED BY USE OF SINGLE AND MULTIPLE BULLS

Items compared	Single bulls	Multiple bulls
Number bulls used	19	77
Bulls per herd	1	4+
Number cows—spring count—all	1803	1442
Number cows per bull	28.2	18.7
Cow fertility record:		
Dry cows (per cent)	13.0	18.7
Cows with calf (per cent)	87.0	81.3
Live calves at birth (per cent)	84.9	78.2
Calves weaned (per cent)	82.5	76.9
Calf loss to weaning[1]	5.1	5.4
Bull weights—beginning of breeding season[2] (pounds)	1650.0	1503.0
Mean weight loss for breeding season (pounds)	112.0	116.0

[1] Based on fertile cows and weaned calves—includes abortions, stillbirths, and accidental deaths.
[2] Basis 61 weights of single bulls; 71 weights of multiple bulls.

shown in table 6. The station's non-registered or grade herds, bred to multiple bulls, in units ranging from 40 cows and 2 bulls to 136 cows and 6 bulls, was compared with breeding herds presented in tables 4 and 5, where a single bull was in a herd. Good strong breeding bulls 2 years old or over were used with these multiple bull herds, and the bulls were kept well distributed among the cows during the breeding season.

Table 6 shows that the multiple bull herds had 5.7 per cent less cows with calf than the single bull herds. This difference is statistically significant ($P < .01$). Approximately 9 more cows conceived per bull in the single bull units than in the multiple bull units. These results indicate that a low calf crop in certain instances can be a management problem and that even with good management practices there will be a lower calf crop from multiple bull herds. It is probable that much of the variation in calf crop percentages in

various sized ranches noted by Wilson et al. (1928) can be accounted for by use of pasture breeding multiple or single bull breeding herds. The smaller ranches with less than 100 cows would resort more frequently to pasture or single bull herds while the larger ranches with more than 450 cows would have to depend on multiple bull herds for breeding. Even some of the large ranchers would do well to resort to pasture breeding if a raise of approximately 20 per cent in calf crop indicated by Wilson or even the 6 per cent observed in this study could be obtained.

The bulls in the single units were heavier individuals than those in the multiple units but the differences in summer weight losses were not significant.

Recommendations

On the basis of this study, the following recommendations should aid the rancher in raising the production level from the standpoint of calf crop percentage:

1. Cows should be identified by proper brands, or marks, so that shy breeders can be eliminated from the herds at an early age. Good producing cows may be kept until at least 10 years of age without loss of fertility.

2. Cows that fail to produce calves in 2 successive years should be culled from the herd. This is especially true in the 4- and 5-year-old groups.

3. Where practical, it would be advisable to test bulls for semen quality before the breeding season so that poor breeding bulls can be eliminated from the herd.

4. There is an advantage in using bulls 4 years old or over of proven breeding ability. This is not only true for proven fertility but by the time one calf crop has grown out the rancher has a chance to judge the value of the bull's calves as meat producers.

5. The establishment of small breeding pastures capable of maintaining herds of about 30 cows each is to be recommended as a means of increasing the calf crop.

Summary

A study of the breeding and calving records at the U. S. Range Livestock Experiment Station, Miles City, Montana, was made on 4,753 cow years over an 18-year period. The average calf crop was 83.1 per cent. The effect of yearly variations due chiefly to environmental causes was statistically significant.

Analysis showed that there was not a significant effect of age of cow on fertility. It was shown that over 50 per cent of the shy breeding cows could be identified by the time they reach 4 years of age and approximately 80 per cent by 6 years of age. Reactors to brucellosis and deaths on the range were

more numerous in the 3- to 6-year-old age than in the 7- to 11-year-old group.

There was a highly significant difference between bulls in per cent calf crop and a variation from 45.5 to 94.0 per cent was observed. Age of bull did not have a significant effect on calf crop percentage but the older bulls lost increasingly more weight during the breeding season.

In a study comparing single and multiple bull breeding units, single bull herds had approximately 6 per cent more calves than multiple bull herds.

Recommendations to the range cattle producer are proposed that should aid in raising the calf crop percentage on his range.

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RECORD OF PROCEEDINGS OF THE 36TH ANNUAL MEETINGS OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

THE meetings were held at the Hotel Sherman in Chicago, on November 30, and December 1, 1943. Interest in the meetings was excellent, 245 members and guests registered in attendance.

The scientific papers that formed the basis for the sectional meetings are published in abstract form in the JOURNAL OF ANIMAL SCIENCE, Vol. 2, pages 356–377. The general sessions were well attended and the topics presented were timely and much appreciated. A record of the business conducted by the Society and some items of interest to the membership are presented in the following pages.

PRESIDENT'S ADDRESS

SOME INTERRELATED PROBLEMS OF THE ANIMAL INDUSTRY AND OF HUMAN NUTRITION IN THE WAR EMERGENCY[1]

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THE principal over-all job of the livestock industry is to provide food for man. It has met the stepped-up demands of the war emergency in a remarkable manner despite shortages of labor, machinery, and of certain critical feed ingredients. These shortages are likely to become more acute. Disease problems also increase as the animal industry is pushed for maximum production.

But the most serious problem of all is concerned with the general feed supply situation in relation to livestock numbers. In spite of exceptional production during the last few years, we are using up our supplies faster than we are replacing them. Some liquidation of livestock is inevitable. In fact it is now occurring in certain areas, namely in the Northeast and on the Pacific Coast, where price policies and transportation problems have already created a serious feed shortage.

Of course this liquidation of livestock can be postponed by drawing heavily on our last reserves of human food, namely our wheat surplus. But certainly this would be an act of folly, particularly when we are obligated to supply as much food as possible to war-torn Europe.

[1] Condensed from a talk presented to the meeting of the American Society of Animal Production on November 30, 1943.

In fact, we may be called upon to decrease animal production beyond that dictated by available feed supplies, so that fewer people in Europe will starve. Suitable land will sustain far more people in producing food crops for direct human consumption than in growing crops for meat, eggs and milk. Animals concentrate the proteins, minerals and vitamins of food crops into products which are more palatable, and to a certain extent more digestible. But in consuming crops and products which can be made suitable for man, a large wastage of these nutrients is involved. When cereals are fed to the most efficient animal converter of energy, the hog, only 15 to 25 percent of their energy is recovered in the edible product.

At the present time we have a shortage of meat and milk in terms of consumer demand, but there is, nevertheless, more milk, meat and eggs available for civilian consumption than there was during pre-war times. Consumer demand is by no means identical with nutritional need.

There is no question but that man prefers meat and other animal products to beans and vegetables, but we may be called upon to get along with less in the interests of feeding more people. This is what England was obliged to do. Her experience proves it can be done without nutritional disadvantage.

If we are compelled to move in this direction, there are differential factors among animal enterprises that should be taken into account. Certain feeding operations take food away from man; others, such as the range feeding of cattle do not. Certain animal products, such as milk, are nutritionally more important than others. Thus, from the standpoint of both agricultural and nutritional policy, any liquidation of livestock should be on a differential basis, taking account of the efficiency of conversion of food resources in terms of land, labor and feed, and of nutritional considerations as well. Obviously many factors are here involved.

Certainly the livestock industry has a real stake in these possible developments. It has an obligation to aid in changes which are dictated by sound policy in a war emergency, and for reconstruction post-war. It also has a justifiable interest to see that this policy takes full account of all of the factors concerned.

In the present situation there is an obligation to see that feed supplies are utilized as efficiently as possible. On the contrary, with high returns for animal products, we tend to be wasteful of feed. The heavy fattening of meat animals is a very inefficient use of the basic food supply in terms of nutritional needs. Particularly with the better use of roughage and pasture, economies can be made in the use of concentrates in dairy feeding. A lower milk yield may have to be accepted, but over-liquidation can be avoided.

Further, no animal products which are suitable for human food should

be wasted. Here again marked savings in terms of the human food supply could be effected. For example, much more of our skimmilk could be brought into human use.

If the various factors which may force a decrease in livestock production are not given attention now, the danger is that the liquidation, when it comes, will go too far, with serious nutritional as well as economic consequences. The present situation, if left to take its course, will tend to result in eliminating the dairy cow first. Controlled and orderly liquidation is essential.

A particular reason why, in terms of post-war service, the livestock industry should be basically maintained, is that we will be called upon to furnish foundation stock for the rehabilitation of the flocks and herds of Europe. In this connection, also, trained personnel will be required. This personnel must include those skilled in general livestock practices and also in special techniques, such as artificial insemination. They must be men who are capable of adapting their knowledge and skills to new situations. Some of these men are already being trained. More will be needed if the programs of UNRRA and the United Nations Food Conference become a reality. These needs must be taken account of in our teaching.

During the war emergency a greatly increased emphasis has been placed on human nutrition and upon the nutritional quality of food products. It is clear that this emphasis will continue. Food production and food manufacture will be increasingly geared to human needs as well as preferences. These facts call for coordinated studies of related problems of the animal industry and of human nutrition.

To serve the needs of our army and for shipment abroad, new animal products and new methods of processing, preserving and packaging, have been developed. The place of these new products and procedures for peacetime use is a subject which deserves intensive research, taking into account processing and marketing considerations, consumer acceptance and needs, and nutritive value.

In these days when both man and animals are competing for the same food crops, coordinated studies are needed as to how our basic food resources can be most effectively utilized in an integrated program, which includes both direct consumption by man and also conversion into animal products for man's use. These will continue to be important post-war studies, if we are to play a part in providing the food necessary to restore to health the starving peoples of a war-torn world.

COOPERATION OF THE FIVE ANIMAL SCIENCE SOCIETIES IN THE WAR EFFORT[1]

GEORGE H. HART
University of California

AT THE present time post-war planning is an important subject of the day, although the war has not yet been won. War is a period when peace-time knowledge and organization are put to the test. Their failures are sign posts for future correction. Such sign posts have been encountered already in the fields of agriculture and biology. If heeded and corrected, they may be placed on the credit side of war against its enormous debit.

As a background for the thesis here presented I have drawn heavily on the findings of Dr. Robert F. Griggs, Chairman of the Committee on Biology and Agriculture of the National Research Council. The tireless efforts of this champion of scientific agriculture have succeeded in setting forth clearly the present status of biology and agriculture. From this foundation we may find a suitable program for the future.

Manpower in Scientific Services

At the beginning of this war the War Manpower Commission was dominated to a certain extent by chemistry, physics and engineering. It was not surprising that biology and agriculture suffered as a consequence. This has been partially corrected and on September 23 a distinction between Production and Services Occupations and Professional and Scientific Occupations was recognized for the first time by the Selective Service System.

There is, however, still a long way to go. The Technical Section of the War Manpower Commission does not seem to have much influence and its roster has been weakened by the replacement of scientific men in positions of influence with clerical people from the Civil Service Commission. Evidence that competent people are not being consulted to the fullest extent in the handling of scientific manpower may be seen in the list of Technical and Scientific Occupations rated as critical. In our field, this list does not include Animal Husbandman, Biologist, Botanist, Breeder either plant or animal, Ecologist, Ichthyologist, Geneticist, Nutritionist, or Zoölogist.

The services necessary to medicine and plant industry are covered fairly well, but the list was compiled by persons wholly lacking in knowledge regarding the need of scientific personnel for animal industry.

Financial Problems

The National Research Council has set up a new general committee on

[1] An address delivered November 30, 1943, before the Annual Meeting of the American Society of Animal Production, Chicago, Illinois.

scientific personnel. Except for the biological member this committee is supported by the organizations represented as follows:

American Mathematical Society	$1,000
The American Institute of Physics	3,000
The Geological Society of America	3,000
The Engineering Foundation	2,000
Emergency Funds of the National Academy	3,000

When the committee was in process of formation, Dr. Griggs, the member representing biology, was asked if the biologists could contribute, and was obliged to say no. The National Academy then came forward with $3,000 for this group making a total of $11,000 advanced by them this year to further the special needs of biologists.

Organization of Biologists

The National Research Council has not been able to secure a suitable organization in biology and agriculture for effectiveness in serving the war effort. It was desired to establish a Committee on Biological Research similar to the Committee for Medical Research. During the course of this endeavor the scope of the efforts was gradually narrowed to the field of Food and Agriculture in which certainly there is urgent need for scientific—as opposed to political—counsel.

A large part of this difficulty lies among ourselves in failing to organize and enlist public understanding. We all recognize the compact organization of physicians, physicists, and chemists. The American Institute of Physics, for example, has effectively mobilized physicists. The officers of this group, backed by its organization, can speak with authority for all physicists, but there is no one who can speak for any considerable segment of either biology or agriculture. Physics was not always so well integrated. In its report of a decade of progress The Institute shows that in 1931 physics was in much the same condition as biology today. In addition to the difficulties faced by physicists before the war, biologists lack the ability to assure that the armed forces obtain required biological services, or to see that individual biologists are put into the places where they can utilize their highest skills. The physicists' report, slightly abbreviated, said:

The Institute originated in the pressing need for cooperation between the American societies of physics which became apparent in 1930 and 1931. There were then operating these trends:

1. A notable and gratifying increase in American research calling for an increased number of pages in journals without adequately increased income to pay the costs entailed.

2. A growing tendency for physics to "split up."

No responsible person could contemplate these trends without grave concern. Must the results of research be suppressed through lack of funds? Must there be an increasing number of overlapping but unconnected societies for physicists to pay dues to? Would all profitable applications of physics appear under some other name rendering no recognition and no financial support to the parent science? Did these many groups have no common interests and objectives which they could attain better together than separately?

The thought of a community or association of cooperating societies emerged from the discussions of a joint committee which met to consider these challenging questions. It then became apparent that financial aid could be attracted much more readily by a single unified request than by a multiplicity of small solicitations. Mr. Francis P. Garvan, President of the Chemical Foundation, gave Dr. Karl T. Compton and Dr. George B. Pegram to understand that that Foundation would extend generous financial help to all of physics but not to a part of it.

The societies adopted the committee's recommendation that an "American Institute of Physics" be founded to provide a mechanism to combine their strength for common objectives, to study the publication problem, to obtain financial support, and to halt the dispersive trend of physics. The reader of this report (1942) is invited to envision his own picture of what condition would have resulted from the old trends, and to contrast it with the demonstrated strength and efficiency of the present organization.

Should we undertake the formation of a comparable institute in our field? It is self-evident that such an institution, once well-established, would be beneficial to all concerned. But the difficulties of organization are much greater in the case of the biologists than those the physicists had to meet.

The American Institute of Physics was established through the cooperation of four societies. There are twenty-five societies in the Division of Biology and Agriculture! This is indication of the comparative size of the fields covered. An organization in the field of physics comparable to biology and agriculture would include all physical science—chemistry as well as physics and engineering, engineering being the applied side of physical science as agriculture and medicine are the applications of biological science.

The first preliminary toward organization is to determine the unit to be included. Should we undertake to consolidate all biology including agriculture and the pre-medical disciplines? Or should we set up institutes of plant science, including the pure and applied fields, and of animal science? Or should we organize around botany and zoology and around agriculture and what we might call "premedical science?"

There are advantages and disadvantages to each of these plans. Some con-

siderations bearing on this question, as they had come to Dr. Griggs through letters and comments, were published in *Science* for December 18, 1942.

He believes if we could answer with assurance the one primary question: What is or are the proper unit or units for the organization of the life sciences, we should be well on our way toward the organization we need.

The Role of Government versus Institutions of Learning

We have witnessed the activity and speed with which the government agencies (in our case particularly the Department of Agriculture) have changed in a few years. The old conservative, sound research organization has been pushed aside by the new so-called progressive agencies.

For the past generation we have tended to look for guidance from Washington and on the whole it has justified our confidence. Further dependence on this source might be leaning on a broken reed if present trends continue. The weakest spot in the country in applied biology, except for numerical strength, might be in Washington. This is by no means due to a lack of ability of the individuals involved but to the timidity engendered by bureaucracy.

It would seem, therefore, that the universities, endowed institutions, and industrial foundations would be justified in planning their own post-war developments. Research is needed along so many lines in the very broad field of animal husbandry that it is difficult to place any particular group of projects ahead of others. Range livestock problems and their relation to forestry and public domain land management would be close to the top of any list. These involve the much abused words overgrazing and erosion, also type of ground cover, brush burning, rainfall run off and stream flow. They extend into the plant field, soil physics and engineering.

Careful consideration might be given to the separation of agriculture from biology. The volume of research going on in agricultural sciences is comparable to that in medical sciences.

Additional university fellowships in agricultural science are needed and an improved understanding in the distribution of some of those now available. Post-doctoral scholarships, including travel allowances, have real possibilities. We need to search the country for brilliant minds having a live interest in agriculture. Agricultural science is competing poorly with physics, chemistry, and medicine for the limited number of brilliant young men available. It is possible to seek men leaning toward the physical sciences, for example, and indoctrinate them in the agricultural field. The Guggenheim Foundation has been quite successful in seeking men for its fellowships.

Shrinkage of Endowment Income

It is important to recognize trends. This association could devote its ef-

forts to a certain project. The results accomplished with identical effort would depend on whether or not this project was going with a trend, attempting to guide a trend, going against a trend, or not involved with trends.

We are in a financial trend wherein return from endowment funds is shrinking and evidence points to low interest rates for a long time. High taxes on earnings will continue. Research will be increasingly supported from current income while the curve of endowment income is going down. Corporations can make grants in aid of research in prosperous years and have 50 to 80 percent of such grants come out of excess profit taxes. The privately endowed institutions will be in need of help from current profits of industry even more than publicly supported institutions. Such competition is worthy of our steel because ability and results are wanted and this will supersede such considerations as loyalty to alma mater.

The recent decision of Swift and Company to support research is an important case in point. Granting a total of one million dollars was discussed but finally two hundred thousand was agreed upon for this year with more to follow. The careful thought given to the method of distributing the money shows that the importance of basic science attack on the problems was clear in the minds of the donors.

We are torn by conflicting viewpoints within our immediate groups which can be readily brought together by clear thinking on the overall picture.

The feeling of futility in many academic circles as the all-out war program developed in this country is explained in a single verse in a recent issue of the *Atlantic Monthly* by Leonard Bacon entitled:

THE NEW SCHOLARSHIP

You may ask us why our work is brittle
And shatters at the slightest touch.
We think too much about too little
And think too little of too much.

The intolerance of brilliant research men in narrow fields to even the discussion of broad gauge problems in their general fields is to be deprecated. On the other hand we need men to develop minutia and others to integrate the whole. But integration of the whole is important now. All along the line education needs to consider collectively how it can best be of servic to this Democracy. It has had a tendency to figure how much money the American people will stand for education and how quickly it could be obtained.

The Five Societies

With this rather prolonged background I am now ready to discuss the title of the paper.

It is my opinion that biology is too big with too many incoördinated ramifications to go together all at once. There are, however, rather definite basic and applied fields that might start independently to think collectively.

Our five societies consisting of:

The American Society of Animal Production
The American Dairy Science Association
The American Poultry Science Association
The American Veterinary Medical Association
The United States Livestock Sanitary Association

represent the applied field in animal science quite well. Others might be included as for example the parasitologists, range-management specialists and economic vertebrate zoölogists. A few years ago the range-management specialists held a rather extended conference at Ephriam, Utah, on almost the same dates that the animal husbandmen were meeting at Miles City, Montana, each oblivious of the other when their problems in that section of this broad country were along the same lines. The prolonged battle between animal husbandry and forestry since the latter was established is largely one of conflicting personalities with love of plant life on one side and plant utilization by animal life on the other. The aims and goals of both sides are not in serious conflict. The same applies to the economic vertebrate zoölogists in their wild-life management programs. In some parts of the far west deer have become a scourge to crop and livestock production. Their own population density in relation to feed supply has caused great mortality in some areas. Idealism is having a terrible time to prevent realism from tkaing the helm to correct the situation. Statesmenship and wisdom at the top and proper organization would readily meet the issue.

In our work on the Committee on Animal Nutrition headed by President Maynard and also the Committee on Animal Health, both appointed by the National Research Council, we are constantly presented with overlapping problems.

Animal nutrition and health are involved with physiology, genetics, bacteriology, animal and poultry husbandry management and veterinary medicine to name some of the more important fields. In subcommittee appointments we are crossing association lines in the personnel to assure broader consideration of the problems.

These five associations have an inter-association council organized for the war effort through which the National Research Council groups would like to work. Most needed is constructive thinking over the broad field to develop integration.

This inter-association council needs to be strengthened, possibly numeri-

cally as well as financially. Any matter that involves more than one association probably should be submitted to the Council for advice before adoption. An example is the report of the special Committee on Recognition of New Breeds of this Association to be acted upon at the business meeting.

This whole matter is one for further study by the Executive Committee. We have the best skeleton framework for organization of any of the groups in biology. If it can accomplish a constructive program it will constitute a lead for other groups to follow and might finally result in organization of the whole of biology and agriculture.

It will aid in the war effort but may see its greatest service after the war is over. The goal is a worthy one; it will reduce human and animal suffering and add untold millions to the national wealth.

SUMMARY OF THE MINUTES OF THE THIRTY-SIXTH ANNUAL BUSINESS MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

A. D. WEBER, *Secretary*

THE meeting was called to order by L. A. Maynard, President, at 2:00 p.m., December 1, 1943 in the Hotel Sherman, Chicago, Illinois. There were 74 members present at this session. Previously, 245 persons had registered for the program sessions.

The Treasurer's report showed a balance of $5,222.20, which represented an increase of $342.11 during the year. It was pointed out, however, that this gain probably will be needed during the coming year to offset the increased cost of publishing the JOURNAL OF ANIMAL SCIENCE.

A special auditing committee consisting of N. R. Ellis and W. P. Garrigus reported that the records and annual report of the Treasurer were examined and found to be complete, orderly, and accurate.

Unanimous approval was given to the report presented by W. E. Krauss in behalf of the Committee on Investigations. This report included a recommendation that a brief digest of important articles published in the Proceedings and dealing with the conduct of nutrition investigations be published in the JOURNAL OF ANIMAL SCIENCE, and that each year a supplement containing a list of new articles on methods and techniques be prepared by the Committee on Investigation and published in the JOURNAL. It is intended that these supplementary lists include noteworthy titles from the world's scientific literature.

The report of this committee reiterated a thought expressed in the report of the Committee on Investigation last year, namely that while research activities must be directed so far as possible to problems of immediate con-

cern to the war effort, the thread of long-time, fundamental investigations should not be broken. It was suggested that encouragement be given to research in the following fields: (1) Relation between nutritional failure and pathology; (2) synthetic diets for all classes of livestock; (3) determination of minimum requirements for each species; (4) the effect of environment on resistance to disease; (5) relation between criteria used in judging and performance and quality.

The report of the Committee on Instruction dealt with suggestions concerning post-war training programs in Animal Husbandry. Some of the suggestions were used as the basis for the papers presented at the 1943 Teaching Session. Others were listed for the guidance of the 1944 Committee on Instruction. The importance of developing strong post-war curricula for both graduate and undergraduate students was emphasized and the need for defining teaching objectives was pointed out.

No report was presented by the Committee on Extension.

A mimeographed report outlining plans of the Committee on Information with reference to publicity for papers presented at the annual meeting was submitted in behalf of this Committee by R. C. Pollock and H. H. Biggar. Included in the report was a list of 84 publications to which one or more articles will be sent.

L. A. Weaver, Chairman of the Committee on Membership, reported that 55 new members were added during the year. Total members of the Society number 578. In addition, 176 non-members subscribed to the JOURNAL OF ANIMAL SCIENCE in 1943.

Resolutions prepared by the Special Committee on Necrology on the deaths of four members appear elsewhere in this issue of the JOURNAL.

R. S. Glasscock presented in behalf of the Special Committee on Meats Investigation, comprehensive recommendations concerning meat research in the emergency and the post-war period. Mimeographed copies of this report may be obtained from R. C. Pollock, National Livestock and Meat Board, Chicago, Illinois.

Unanimous approval also was given to the report presented by R. H. Lush for the Special Committee on Pasture and Range Investigations. This report stressed the importance of State and regional programs to increase forage production and utilization through efficient use of seed and other supplies during the war emergency.

The following resolutions recommended by the Special Committee on Evaluation of Feeds were approved by unanimous vote:

1. That more research should be initiated designed to find a practical chemical description of feeds which will more accurately indicate nutritive values than the present standard feeding stuffs analysis. Because of the im-

portance of the carbohydrate fractions of the major sources of energy and the misleading nature of the present scheme of analysis, it is recommended that the Committee on Evaluation of Feeds for the coming year give this problem special consideration.

2. That the compilation and analysis of existing data on the composition and digestibility of feeding stuffs at present in progress at the West Virginia Agricultural Experiment Station under Dr. B. H. Schneider and initiated at the request of the Committee on Nutrition of the National Research Council, will be an important contribution in this field. All measures to hasten the completion of this work are strongly endorsed by the Society.

G. H. Hart, Chairman of the Committee on Registration of Animals Produced by Artificial Insemination and Recognition of New Breeds, moved in behalf of the majority of the members of this Committee that its report be referred to the Inter-Association Council on Animal Disease and Production and the committee continued in an advisory capacity. Doctor Hart pointed out in discussing this report that after being considered at the 1942 annual meeting, it was published in the JOURNAL OF ANIMAL SCIENCE (Vol. 2, No. 1, pp. 92-94), with the recommendation that it be given further consideration at the 1943 annual meeting. The motion passed by unanimous vote.

W. V. Lambert, the representative of the Society on the Inter-Association Council on Animal Disease and Production, spoke briefly concerning the aims and accomplishments of this group. He stated that the Inter-Association Council consists of one representative from each of the following national associations:

American Dairy Science Association
American Society of Animal Production
American Veterinary Medical Association
Poultry Science Association
United States Livestock Sanitary Association

The objective of this Council is to coordinate the activities of the member associations for the protection of the livestock industry and for increasing its productive capacity.

It was explained that the Inter-Association Council is to be financed by contributions from its member associations on the basis of $25 for the first 500 members and one cent for additional members. Unanimous approval was given to a recommendation of the Executive Committee that the American Society of Animal Production contribute on this basis.

H. C. McPhee presented the report of H. W. Marston, the Society's representative to the National Research Council. The report, which was approved unanimously, summarized the proceedings of the annual meeting of

the Division of Biology and Agriculture of the National Research Council, in Washington, D. C., on April 10, 1943.

A report given at this meeting which was of particular interest to our Society was that of L. A. Maynard on the work of the Committee on Animal Nutrition. This Committee has been very active and since April, 1942 has published six reports on timely nutritional subjects. Three additional reports are in press.

Ralph G. Schott, Acting Editor of the JOURNAL OF ANIMAL SCIENCE, reported briefly for the Editorial Board. He discussed the processing of papers submitted for publication and urged members to use greater care in the preparation of manuscripts.

The following officers were elected:

President—L. A. Weaver
Vice President—A. D. Weber
Secretary-Treasurer—W. V. Lambert

The Constitution provides that the President and Vice President shall hold office for one year and the Secretary-Treasurer for not less than three years.

Upon motion the following report of the Resolutions Committee, W. E. Krauss, Chairman, was adopted unanimously:

1. That thanks be extended to the management of the Hotel Sherman for the facilities, accommodations and courtesies provided under trying circumstances.

2. That thanks and appreciation be extended to invited speakers and guests and to all those who contributed to the program and arrangements for the meeting.

3. That thanks and appreciation be extended to the Committee on Information and especially to R. C. Pollock and the National Livestock and Meat Board for loaning Mr. Biggar's excellent services to the work of the Committee and paying the costs incidental to this work.

4. That the American Society of Animal Production propose to the American Dairy Science Association, the Poultry Science Association, the American Veterinary Medical Association, and the United States Live Stock Sanitary Association that these Societies, along with the American Society of Animal Production, prepare a joint statement on manpower required properly to facilitate the activities represented by these societies and submit such a statement to the War Manpower Commission.

5. That because of the imbalance between livestock numbers and feed supplies it is obvious that orderly liquidation of livestock numbers on a differential basis is necessary.

6. That to facilitate orderly liquidation of livestock, consideration must

be given by government agencies to supplying necessary manpower for packing plants, to differential requirements in geographical areas, and to methods for making more utility grade carcasses available to consumers.

The following motion was passed unanimously: "That the Executive Committee consider the advisability of setting up in the Secretary's office an employment bureau to help in the replacement of members returning from the armed forces, with power to act."

A unanimous vote of appreciation was extended to the present officers for their work during the past year and a unanimous vote of confidence was given in support of the incoming officers.

CHAIRMEN OF COMMITTEES FOR 1944

Committee on Investigation.....W. E. Krauss (Ohio)
Committee on Instruction.....J. S. Coffey (Ohio)
Committee on Extension.....Claud Harper (Indiana)
Committee on Membership.....A. D. Weber (Kansas)
Special Committee on Information.....
.....R. C. Pollock (Nat'l. Livestock and Meat Board, Chicago)
Special Committee on Cooperative Meat Investigations.....
.....R. S. Glassock (Florida)
Special Committee on Pasture and Range Investigations.....
.....R. H. Lush (Nat'l. Fertilizer Assoc., Washington, D. C.)
Special Committee on Evaluation of Feeds.....
.....E. W. Crampton (Macdonald College, Quebec)
Special Committee on Artificial Insemination and Recognition of New Breeds.....G. H. Hart (California)
Special Committee on Necrology.....C. W. McCampbell (Kansas)
Representative on National Research Council .H. W. Marston (U.S.D.A.)

MEMORIALS

DR. M. JACOBS

Dr. M. Jacobs was born in Pennsylvania January 6, 1879. Graduated from the University of Pennsylvania School of Veterinary Medicine 1899. Resident Surgeon, University of Pennsylvania Veterinary Hospital 1899–1900. Inspector, U. S. Bureau Animal Industry 1900. Part time instructor in Veterinary Science, University of Tennessee 1900–1904. Professor Veterinary Science, Iowa State College 1904–1905. Part time instructor in Veterinary Science and Animal Husbandry, University of Tennessee 1905–1915. State Veterinarian, Tennessee 1915–1921. Head Department of Animal Husbandry, University of Tennessee 1921–1937. Dean of Agriculture and Head of Animal Husbandry, University of Tennessee 1937–1943. Doctor Jacobs also served different veterinary organizations and groups in several important positions including treasurer of the American Veterinary Medical Association from 1918 to the time of his death.

The esteem in which he was held personally by his fellowmen and their estimate of the worth of his professional labors are indicated in the excerpts from a resolution adopted March 28, 1943, by the Knoxville, Tennessee, Rotary Club which follows:

"A most companionable associate of mankind. He was a pattern of good citizenship without realizing he was one. He was modest—a gentleman with all classes and all ages; unostentatious, though generous in his civic and professional contributions. His friends were legion in community, state, and nation. His scientific background guided his economic and social decisions. This background accounted for his wide range of successful contacts in administrative and in public relations.

"Dr. Jacobs' ability to translate nature's laws and scientific information to all rural classes established him as a master teacher and leader. For more than forty years his classroom and public messages inspired students and farm people to higher objectives of contribution and living."

Dr. Jacobs passed away at Knoxville, Tennessee, March 22, 1943.

ELMER SETH SAVAGE

Professor Elmer Seth Savage was born in Lancaster, New Hampshire, on June 15, 1884. Died at Ithaca, New York, November 23, 1943. He grew up in that State on the farm of his father, John Savage, and was graduated in 1905 from the New Hampshire College of Agriculture with the degree of Bachelor of Science in Agriculture.

After teaching animal husbandry for two years in the Baron de Hirsch Agricultural School in New Jersey, he took up graduate studies at Cornell University, as assistant in the Department of Animal Husbandry. In 1909 he received the degree of Master of Science in Agriculture; and in 1911, the degree of Doctor of Philosophy from Cornell University. In 1933 he was given the honorary degree of Doctor of Science by the University of New Hampshire.

At Cornell he advanced rapidly through the successive ranks of instructor and assistant professor, and in 1913 was appointed to a professorship in the Department of Animal Husbandry. In all his teaching and research at Cornell, Professor Savage specialized in the feeding and management of dairy cattle. He developed the well known Savage Feeding Standards, proved with the assistance of others that 16 to 18 percent protein provided ample protein for dairy cows fed silage and good quality mixed hay; was largely responsible for the development of the Cornell Calf Starter and recently he had conducted experiments to determine the effect of making decided changes in the formulas of mixed dairy feeds and had shown that considerable change could be made without lowering milk production provided that the contents of digestible protein of fat and of total digestible nutrients are maintained in the formula. He was a leading advocate of the manufacture of mixed livestock feeds according to "open formula."

Professor Savage wrote extensively. In addition to the many articles published in farm papers and to bulletins he was the author of the books "Feeds and Feeding Manual" (1913); "Feeding Dairy Cattle" (1917); and "Better Dairy Farming" (1923), the latter in collaboration with Dr. L. A. Maynard.

While on sabbatical leave from Cornell University in 1931, Professor Savage made an extensive trip into northern Africa and Europe to study agricultural conditions and especially dairy farming. During this trip he was an official representative of the United States Government at the World's Dairy Congress in Copenhagen, Denmark.

Professor Savage always took an active part in the activities of farmers in his home county. For many years he operated a dairy farm and developed a purebred Guernsey herd to a 400-pound fat level.

Professor Savage maintained active relationships with many scientific organizations and was a member of Sigma Xi; Gamma Alpha; Alpha Zeta and Kappa Sigma.

BENJAMIN W. RODENWOLD

Benjamin W. Rodenwold was born at O'Neill, Nebraska, March 21, 1895. Died of a heart attack at Corvallis, Oregon, September 2, 1943. He received Bachelor of Science degree from

the University of Nebraska in 1920 and soon thereafter joined the animal husbandry staff of the Oregon State Agricultural College where he spent the remainder of his life except for time out to study for the Master's degree which was granted him by Iowa State College in 1929. A brief summary of his work at Oregon State College reads:

"In addition to teaching responsibilities, particularly in the elementary courses, upon his initial appointment Professor Rodenwold was assigned the responsibility of the management of the farm land allocated to the Department of Animal Husbandry. He had unusual talent for this work. His relationship to the students continued to grow and upon the organization of the livestock work at this institution into a division, Professor Rodenwold took over greater teaching responsibilities. He continued to be the specialist on beef cattle but was given the full responsibility of the training for livestock judging teams and taught other advanced courses. He also was assigned the responsibility of all of the farming operations for the Departments of Animal, Dairy and Poultry Husbandry, an obligation which he discharged to the satisfaction of all specialists concerned. This in itself is a tribute to his personality.

"During all this period Professor Rodenwold made many valuable contributions in an attempt to develop the beef cattle industry west of the Cascade Mountains in Oregon, and it can be safely said was to a considerable extent responsible for the development of the data which has made it possible for the extension specialists to develop that industry."

ROBERT BYRON HINMAN

Robert Byron Hinman was born at Colborne, Ontario, Canada on September 16, 1888. After he was awarded the Bachelors degree in Scientific Agriculture at the Ontario Agricultural College in 1915 he was Farm Bureau Agent in the Ontario Department of Agriculture until 1920. During part of this time he served overseas in the Canadian Army in World War I. He received the M.S. degree at Iowa State College in 1920 and in the same year came to Cornell University where he served as Instructor in the Animal Husbandry Department. He was made Assistant Professor in 1921 and Professor in Animal Husbandry in 1937. In 1926 he received the Ph.D. degree at the University of Wisconsin. His thesis work was a study of the effects of chronic alcoholism upon inheritance in the rabbit, a difficult problem involving the controversial question of the inheritance of acquired characters. He continued this work at Cornell.

Doctor Hinman was in charge of the teaching and research work in beef cattle and meats. His sound judgement earned him the respect of Animal Husbandmen throughout the country and his knowledge in these fields of endeavor caused him to be appointed on many professional committees. He firmly believed that the agriculture of New York State would benefit by a more diversified type of farming and he did much missionary work, with success, on the value of beef cattle and the home slaughtering of meat. Many of his students are carrying on with this good work throughout New York and neighboring States.

He was also interested in the development of animal breeding work in the College. He was instrumental in bringing the Robert C. N. Auld collection of books and manuscripts on this subject to our library while his own extensive and valuable collection of books has become the treasured possession of the Animal Husbandry Department. By the desire of his wife and family it forms the R. B. Hinman Memorial Collection. He retired on June 30th, 1943 and passed away on July 25th, 1943 after a long illness.

These are but the bare facts of his life. Those who knew him well were aware of many years of pain and increasing disability bravely borne. His readiness to help student or colleague with any difficult problem endeared him to all and his enthusiasm was infectious. His fund of anecdotes, never repeated, and carrying a wealth of experience and apt interpretation were part of the educational equipment which he used to such good purpose. But those who knew him best sometimes noted that his expression showed how keenly aware he was of the irony of his wit if it were applied to his own circumstances. We honored him for it and for his constant effort to prevent his troubles from warping his judgment and from impairing his usefulness. We honored him for his fortitude and mourn the loss of a brave colleague.

NEWS AND NOTES

The Review Committee's Report on the Conference on Cooperative Meat Investigations is now ready for distribution. This report includes 68 summaries and 375 abstracts of the work carried on by the conference members during the five years from 1937 to 1942.

It includes the following sections:

	Summaries	Abstracts
Methods	11	51
Beef	10	80
Pork	23	91
Lamb	6	16
Grades & Measurements	4	13
Cookery	5	20
Nutrition	9	104

It is published as Volumes 3 and 4, and the two volumes are available at the price of $10.00. Those who have Volumes 1 and 2 undoubtedly will be interested in having the supplementary report. This may be obtained by writing to R. C. Pollock, National Live Stock & Meat Board, 407 South Dearborn Street, Room 825, Chicago, Illinois.

Dr. Fred F. McKenzie has recently resigned as head of the Department of Animal Husbandry, Utah State Agricultural College to become Director of Livestock Research with the Superior Products Co., Golden, Colorado.

James M. Coon, formerly wool specialist with Farm Credit Administration, and more recently in charge of wool grading and standardization for FDA, has resigned.

A. S. Severson, of the N. Dak. State College animal husbandry staff has resigned.

N. W. Hilston, formerly of the dairy husbandry staff, N. Mex. Agri. College, is now asst. prof. of animal industry at the University of Arkansas.

C. R. Kyd, formerly county agri. agent in Randolph County, Mo., is now asst. extension animal husbandman at the University of Missouri, Columbia.

R. C. Tom has been made head of the animal husbandry department, Colorado Agri. College. He has been acting since H. B. Osland resigned some time ago.

C. V. Wilson is acting as extension animal husbandman, West Virginia University, while Benj. F. Creech is occupied with the farm labor program in West Virginia.

Paul P. Hite, sheep extension specialist, University of Tennessee, was elected president of the American Southdown Association at the recent annual meeting in Chicago.

Dr. John R. Mohler recently retired as Chief of the U. S. Bureau of Animal Industry after a service of more than 40 years. He was succeeded by Dr. A. W. Miller.

Edgar Martin, formerly of Arkansas, is now associate animal husbandman, N. Dak. Agri. Expt. Station, and superintendent of the substation at Hettinger.

M. I. Wegner, formerly of the Texas station is now assistant animal nutritionist, N. Dak. State College.

Russell G. East, general agri. agent, Pennsylvania R. R. Co., with headquarters at Richmond, Ind., died suddenly on November 3. His son, Lewis P. East, has succeeded to the vacancy.

George A. Branaman of the Michigan State College animal husbandry staff was on special assignment with the Food Distribution Administration last summer.

Marshall C. Heck of the Massachusetts State College became a member of the technical staff of the National Live Stock & Meat Board on October 15. Lowell E. Walters of Louisiana State University takes his place on the Massachusetts staff.

Ural G. Bee, formerly of the animal husbandry staff, West Virginia University, is now assistant animal husbandry specialist in the University of Maryland Extension Service.

Frederick W. Wilson, head of the animal husbandry department, University of Nevada for 29 years, is now Acting Dean of the Nevada College of Agriculture.

Leroy Van Horn, recently of the teaching staff at Utah State Agricultural College and formerly at Colorado State College, is now a member of the animal industries staff at Montana State College where he will be in charge of sheep and wool investigations.